TERMINAL 4 CONFINED DISPOSAL FACILITY DESIGN ANALYSIS REPORT (PREFINAL 60 PERCENT DESIGN DELIVERABLE) PORT OF PORTLAND, PORTLAND, OREGON

Prepared for

Port of Portland

Portland, Oregon

Prepared by

Anchor QEA, LLC

6650 SW Redwood Lane, Suite 333

Portland, Oregon 97224

In Association with

Berger/ABAM Engineers, Inc.

NewFields

Ash Creek Associates, Inc.

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LIST OF ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
µg/L	micrograms per liter
AASHTO	American Association of State Highway and Transportation Officials
AOC	Administrative Order on Consent
AOPCs	Areas of Potential Concern
ARARs	Applicable or Relevant and Appropriate Requirements
BATS	Business Analysis Terms Sheet
BMPs	best management practices
bpf	blows per foot
CDF	confined disposal facility
City	City of Portland
CLE	contingency level event
cm/yr	centimeters per year
CMPP	Conceptual Mitigation Plan Proposal
COCs	chemicals of concern
CPT	cone penetrometer test
CQAP	Construction Quality Assurance Plan
CST	Column Settling Test
CSZ	Cascadia Subduction Zone
CWA	Clean Water Act
cy	cubic yards
D_{50}	median diameter
DAR	Design Analysis Report
DO	dissolved oxygen
DOGAMI	Department of Geology and Mineral Industries
DRET	dredging elutriate test
DSL	State of Oregon Department of State Lands
EE/CA	Engineering Evaluation/Cost Analysis
FEMA	Federal Emergency Management Agency

fps	feet per second
FS	Feasibility Study
g/day	grams per day
GAC	granular activated carbon
H:V	horizontal to vertical
IDR	informal dispute resolution
IRM	International Raw Materials
kg/yr	kilograms per year
km	kilometers
km/day	kilometers per day
KMBT	Kinder Morgan Bulk Terminals
LTMRP	Long-term Monitoring and Reporting Plan
LWG	Lower Willamette Group
m/sec	meters per second
MCLs	maximum contaminant levels
MET	Modified Elutriate Test
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mm	millimeters
MNR	monitored natural recovery
MSL	mean sea level
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NTCRA	Non-Time-Critical Removal Action
NTU	Nephelometric Turbidity Units
OAR	Oregon Administrative Rules
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OHW	ordinary high water
PAH	polycyclic aromatic hydrocarbon

PCBs	polychlorinated biphenyls
PCLT	Pancake Column Leaching Test
PEC	probable effects concentration
PGA	peak ground acceleration
Port	Port of Portland
psf	pounds per square foot
PSHA	Probabilistic Seismic Hazard Evaluation
QA	quality assurance
QC	quality control
RAO	Remedial Action Objective
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RM	River Mile
RNA	regulated navigation area
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SBLT	sequential batch leaching test
SPT	standard penetration test
SVOCs	semivolatile organic compounds
T4	Terminal 4
TCLP	Toxic Characteristic Leaching Procedure
TEC	threshold effects concentration
TMDL	total maximum daily load
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

VOCs	volatile organic compounds
WQMCCP	Water Quality Monitoring and Compliance Conditions Plan
WQMP	Water Quality Monitoring Plan

EXECUTIVE SUMMARY

This Design Analysis Report (DAR) and supporting appendices provide 60 Percent Design documents for a confined disposal facility (CDF) proposed to be built in an underused slip at the Port of Portland (Port) Terminal 4 (T4), Slip 1, near Willamette River Mile 4.2. Final design and construction of the CDF is contingent on the CDF being selected as a preferred disposal alternative during the Portland Harbor Feasibility Study (FS) and Record of Decision (ROD). The T4 CDF would have the capacity to hold 670,000 cubic yards (cy) of contaminated sediment from remedial actions in the Portland Harbor Superfund Site. A CDF is a proven technology implemented in the Pacific Northwest at other Superfund sites that provides isolation of contaminated sediments from the aquatic environment and thereby protects human health and the environment.

The 60 Percent Design of the T4 CDF meets the intent of the U.S. Environmental Protection Agency (USEPA) CDF performance standards that were transmitted to the Lower Willamette Group (LWG) and the Port on February 18, 2010, as well as Portland Harbor Remedial Action Objectives (RAOs) and Applicable or Relevant and Appropriate Requirements (ARARs) as they are currently known. The USEPA CDF performance standards and follow-up clarifications by the Port and LWG are reproduced in their entirety in Appendix A. The DAR provides scientific and engineering analysis supporting that the designed CDF is in accordance with USEPA's interim CDF performance standards. An index of the relevant DAR sections where specific CDF performance standards are addressed is provided in Table 5-1.

Overview of CDF Design and Construction

An at-grade CDF having a footprint of approximately 14 acres would be constructed in T4 Slip 1. Sediments to be placed in the CDF would include sediments over-excavated from the berm key area of Slip 1, dredged sediments from T4 Slip 3, and dredged sediment from other Areas of Potential Concern (AOPCs) in the Portland Harbor Superfund Site. Groundwater modeling results show that sediments from ten high-priority AOPCs in Portland Harbor would be suitable for placement in the T4 CDF, as presented in Section 6.4 and Appendix A.

The construction elements of the CDF are shown in plan view and in cross-section on Figures 5-1 and 5-2, respectively.

Construction of the T4 CDF would be completed in three stages:

- **Stage 1** – Slip 1 preparation and construction of the CDF containment berm.
- **Stage 2** – Filling of the CDF with contaminated sediments from Portland Harbor.
- **Stage 3** – Completion of the CDF cover.

The entire project, including berm construction, filling the CDF, and placement of the final cover, is expected to take 5 to 10 years to complete, depending on the schedule of Harbor-wide remedial actions and the availability of suitable dredged material.

CDF Preparation and Berm Construction. Preparation work and construction of the CDF berm is expected to take approximately 1 to 2 years to complete. Initial preparation work consists of demolition and relocation of Slip 1 structures, and re-routing stormwater outfalls. Then the soft sediment in the berm key area will be removed using a clamshell dredge to prepare a stable berm foundation, and the excavated material will be placed in the head of Slip 1. The containment berm will require approximately 290,000 tons of select fill and 95,000 tons of rock for training terraces. The lower portion of the berm will be constructed from the water during the in-water work window, and after the berm breaches the water surface, the upper portion will be finished in the dry with upland equipment. Fish salvage efforts will be conducted in the CDF pond after it becomes isolated from the river.

Filling the CDF. The CDF can confine an estimated 670,000 cy of contaminated sediments, and potentially 30 to 45 percent additional volume depending on the amount of settlement that occurs. It is anticipated that dredged sediment from Portland Harbor remedial action areas would be offloaded from haul barges into the CDF using a high-solids dredge pump, and the make-up water used to prepare the dredge slurry would be drawn from the CDF pond to minimize the head difference between the pond and the river. The offloading facility is expected to be located at the replacement berth on the southern edge of the berm, and would likely be sized to offload 2,000 to 4,000 cy per day assuming a 10- to 12-inch-diameter hydraulic dredge pump, respectively. The filling process is estimated to take up to 4 years.

Covering the CDF. The CDF cover consists of two layers. The lower layer, located directly above the confined dredged sediment, is the import fill layer. This layer is approximately 464,000 cy in volume, and is anticipated to be suitable dredged material brought to the site on haul barges and offloaded as described above. The top of the CDF is the CDF cover layer. This layer consists of approximately 272,000 tons of aggregate from an upland source, brought to the site by truck and/or barge and offloaded mechanically.

Habitat Mitigation. The Port is not proposing any specific mitigation in this document, but acknowledges that the determination of final mitigation requirements for construction of the CDF will be established in consultation with USEPA and its federal, state, and tribal partners after the ROD is issued.

Estimated Cost. The cost to construct the CDF is estimated between $44 and $63 million. The cost range reflects the uncertainties regarding the cost of obtaining 18 feet of imported fill material, to be placed over the contaminated dredged sediment; and to a lesser extent the uncertainties in habitat mitigation costs.

Conformance with CDF Performance Standards

The achievement of CDF performance standards will be verified through the implementation of numerous sampling and monitoring requirements for both short-term activities associated with CDF construction and filling, and long-term activities associated with the operation and maintenance of the CDF after it has been filled and closed. Table 2-1 summarizes the various CDF monitoring requirements.

Short-Term Performance Standards

Short-Term Water Quality. Dredging, filling, and related sediment-disturbing CDF construction activities will be conducted in a manner that meets water quality criteria at specified points of compliance. Proposed monitoring methods, measurement parameters, locations, and frequencies are presented in the Water Quality Monitoring Plan (WQMP; Appendix E), and will be further detailed in the USEPA Water Quality Monitoring and Compliance Conditions Plan (WQMCCP) to be developed during 100 Percent Design. Based on the results of dredging elutriate tests, the favorable monitoring record during the T4 Phase I Removal Action, and the relatively low contaminant concentrations in the berm key area, adverse short-term water quality effects are not expected during T4 CDF construction.

Currently, the filling of the CDF is not anticipated to occur using hydraulic dredging methods. If hydraulic dredging is shown to be a preferable dredging and placement method for certain AOPCs in Portland Harbor, causing return flows of dredging elutriate water to the river, additional water quality analyses will need to be conducted.

Construction Verification. The Construction Quality Assurance Plan (CQAP; Appendix D) provides quality control (QC) measures that will be implemented during construction to verify that the CDF is built in accordance with the project Drawings (Appendix B) and Construction Specifications (Appendix C). Construction QC measures have been developed to verify the following:

1. Design dredge depths and lateral extents are achieved during berm key excavation
2. Design grades, elevations, extents, and densities are achieved during berm construction and CDF filling
3. Demolition of structures and piles is performed as specified, and remaining structures are protected
4. Import material meets specified physical and chemical requirements, depending on its use (Note: import material acceptance criteria will be developed in the 100 Percent Design)

Long-Term Performance Standards

Long-Term Water Quality. The CDF has been designed to ensure that groundwater exiting the CDF meets state and federal chronic water quality criteria for aquatic life, human health fish consumption criteria, and drinking water maximum contaminant levels (MCLs). These water quality criteria are to be met in the porewater of the berm, without dilution in the water column, and in the base case scenario without consideration of biodegradation.

A numerical groundwater model of the T4 CDF was developed to predict the movement of contaminants between the dredge fill and the river for 500 to 1,000 years. The model (MODFLOW/MT3DMS) describes groundwater advection and dispersion, mixing of leachate with rainfall and regional groundwater, adsorption and desorption of contaminants onto berm and aquifer soils, and conservative biodegradation processes in some cases, as presented in Section 6.4 and Appendix A. The model uses site-specific input parameters to the extent possible, including hydraulic measurements of T4 sediments and aquifer materials, Portland Harbor leachate tests, Willamette River gage records, and the physical characteristics of local import materials. A representative suite of Portland Harbor index contaminants were modeled including copper, naphthalene, benzo(a)anthracene, DDx, and Total polychlorinated biphenyls (PCBs).

Groundwater transport pathways are dominated by downward vertical flow through the contaminated dredge fill toward the underlying aquifer and laterally into the berm. The groundwater residence time in the contaminated dredge fill varies from about 20 years along the front and bottom of the CDF, to 200+ years at the rear and upper portion of the CDF. During the model simulation period, the concentrations of all chemicals of concern (COCs) remained below their respective evaluation criteria under the base case scenario of no biodegradation for approximately 500 years or more. When conservatively slow rates of biodegradation are incorporated into model simulations for organic compounds, groundwater exit concentrations are reduced by two to three orders of magnitude. These results indicate the CDF will be protective of long-term water quality. Model sensitivity and uncertainty analyses confirm that model results are robust over a relatively wide range of input parameter values.

Long-Term CDF Stability Performance. Long-term monitoring activities will be conducted to verify that the T4 CDF is structurally stable and performing as intended. Visual surveys of the exposed berm, hydrographic surveys of the submerged berm, water level monitoring of groundwater wells, and settlement surveys will be conducted to confirm the following:

1. The containment berm is geotechnically stable under design static and seismic events
2. The containment berm is resistant to erosion from flooding, vessel waves, turbulence, or other hydraulic forces
3. The CDF is consolidating and settling as predicted over the long term.

1 INTRODUCTION

1.1 Background

The Port of Portland (Port) entered into an Administrative Order on Consent (AOC) with the U.S. Environmental Protection Agency (USEPA) in October 2003 to perform a Non-Time-Critical Removal Action (NTCRA) at the Terminal 4 (T4) site on the Willamette River in Portland, Oregon (Figure 1-1) (USEPA 2003a). The AOC requires the Port to perform an Early Action to address known contamination found in T4 sediment samples during a Remedial Investigation (RI) directed by the Oregon Department of Environmental Quality (ODEQ). In 2005, the Port prepared and submitted the *Terminal 4 Early Action Engineering Evaluation/Cost Analysis* (EE/CA), which provided a comparative analysis of remedial options for T4 (BBL 2005). Based on this information, USEPA, in consultation with its federal, state, and tribal partners, evaluated and selected a Removal Action for T4 that included a combination of monitored natural recovery (MNR), capping, and dredging, with placement of contaminated sediment in a confined disposal facility (CDF) to be built on site in Slip 1. The USEPA-selected Removal Action was detailed in an Action Memorandum prepared by USEPA in 2006 (Action Memo; USEPA 2006a).

The T4 Removal Action process is separate from the Portland Harbor Superfund Remedial Investigation (RI) and Feasibility Study (FS) process, which has been progressing concurrently. Subsequently, USEPA and the Port acknowledged an increased relationship between the T4 CDF and the Harbor-wide RI/FS process. Presently, USEPA and the Port anticipate that final design and construction of the CDF is contingent on the CDF being selected as a preferred disposal alternative during the Portland Harbor FS and Record of Decision (ROD).

The Port submitted a Conceptual 30 Percent Design Analysis Report (Anchor 2006a) and Prefinal 60 Percent Design Analysis Report (Anchor 2006b) for the T4 Early Action consistent with the Action Memo in 2006. In January 2007, USEPA issued a letter to the Port along with comments and directed changes on the T4 Early Action 60 Percent Design. The letter stated that: "…the 60 percent design is not approved, rather to keep the process moving forward, EPA expects that issues identified with the 60 percent design will be resolved with interim deliverables…". The January 2007 USEPA comment letter was the subject of an informal dispute resolution (IDR) process that occurred throughout much of 2007. The November 15, 2007 letter from USEPA to the Port represents the final agreements reached during the IDR process and the agreed path forward relative to the original T4 Early Action 60 Percent Design.

Implementation of the Action Memo is now occurring in phases because many of the design issues required for full implementation are linked to the overall Portland Harbor-wide RI/FS process, which is taking more time than what was anticipated when the Action Memo was issued. For this reason, in a letter to USEPA dated August 22, 2007, the Port requested that USEPA revise the schedule for implementation of the T4 Removal Action to realign the Early Action project with the Harbor-wide RI/FS schedule. The Port also prepared an Abatement Measures Proposal in October 2007 (Anchor 2007a) to detail specific components of the Removal Action that could be implemented as a Phase I action to address conditions at T4 that posed an imminent threat to human health and the environment. In November 2007, USEPA approved the schedule realignment request on condition that the Port would implement the Phase I Removal Action components outlined in the Abatement Measures Proposal (letter dated November 15, 2007 from Deborah Yamamoto, USEPA, to Tom Imeson, Port of Portland). The Final Design of the Phase I Removal Action was completed and implemented in 2008. The Phase I Removal Action consisted of the following activities (see Figures 1-2 and 1-3):

- Dredging and off-site disposal of sediment from within three areas exhibiting the highest chemical concentration at T4. Specifically, these areas were adjacent to Berth 411 and Pier 5 in Slip 3, and north of Berth 414. A portion of the Phase I areas could not be dredged to the planned removal depth due to concerns regarding potential impacts to the stability of the adjacent side slopes and waterfront structures. Therefore, after dredging was completed to the extent feasible, selected areas were covered with a thin layer of sand.
- Dredging and off-site disposal of contaminated sediment in an area adjacent to Berth 410 within Slip 3 to support water-dependent maritime use in a manner consistent

with the Action Memo (USEPA 2006a). Material was removed down to navigational depths of between -39.3 to -41.3 feet National Geodetic Vertical Datum (NGVD).

- Construction of a nearshore cap at the head of Slip 3 in front of and behind the existing timber bulkhead to isolate petroleum-contaminated sediment from aquatic receptors and control a potential ongoing source to Slip 3.
- Stabilization and capping of the Wheeler Bay shoreline to minimize contaminant migration to the river.

These activities were all planned as part of the overall Removal Action at T4 as described in USEPA's Action Memo (USEPA 2006a). The activities were implemented as part of Phase I because they addressed areas within the site that exhibited some of the highest concentrations, presented potential ongoing sources, and/or were not expected to be significantly impacted by the outcome of the Harbor-wide RI/FS process. The remainder of the Removal Action will be implemented as Phase II. Phase II of the Removal Action consists of a combination of dredging, capping, and MNR in areas not completely addressed by Phase I, as well as construction of a CDF in Slip 1. The cap in the head of Slip 3 and the Wheeler Bay shoreline stabilization activities are intended to be the final Removal Action for these areas, consistent with the Action Memo (USEPA 2006a). The areas that were dredged as part of Phase I will be reassessed and, if necessary, addressed further as part of Phase II along with any remaining areas of contamination at T4 including Slip 3, Berth 414, and Berth 401.

At the time of the schedule realignment in 2007, design and implementation of the Phase II Removal Action was based on a Harbor-wide schedule that anticipated resolution of key Harbor-wide issues and submittal of the Draft FS prior to submittal of the Phase II 60 Percent Design. Resolution of key Harbor-wide issues and submittal of the Draft FS did not occur on the timeline anticipated. As such, the Port requested a second schedule realignment for Phase II that was contingent on the issuance of the Portland Harbor ROD (letter dated September 23, 2009 from Tom Imeson, Port of Portland, to Deborah Yamamoto, USEPA). This second realignment was proposed to ensure that the Phase II Removal Action is environmentally protective, cost-effective, and consistent with the Harbor-wide cleanup, especially the design and implementation of the Slip 1 CDF and its associated cost. The Port and USEPA discussed this request through various meetings and letters from September 2009 through January 2010. In the Port's November 23, 2009 letter to USEPA, the Port re-iterated the commitment to implement the T4 CDF action with the following qualifications:

- USEPA selects the CDF in the ROD in accordance with the National Contingency Plan and determines that other sediment from the Portland Harbor Superfund Site can be disposed in the CDF.
- CDF is cost-effective alternative when compared to other Harbor-wide alternatives.
- Other CDF users and a mechanism to finance the significant capital costs for CDF construction are identified.

In a letter dated January 22, 2010, USEPA granted the Port's second schedule realignment request based on the following three conditions:

- The Port shall submit the 60 Percent Design for the T4 CDF by September 1, 2010, using performance criteria provided by USEPA so that this information can be included in the Harbor-wide FS. [Note: The 60 Percent Design for the T4 CDF is the subject of this document.] USEPA agrees to extend the schedule for the 90 and 100 Percent Design and construction of the CDF until after the Harbor-wide ROD is issued. After issuance of the ROD, USEPA, in consultation with the Port, will also develop a schedule for completion of the other components of the Phase II Removal Action at T4.
- Within 30 days (of the January 22, 2010 letter), USEPA would provide both the Lower Willamette Group (LWG) and the Port with a set of performance standards to be used in evaluating all CDF alternatives in the Harbor-wide FS, including the T4 CDF. These performance criteria will address short-term impacts during CDF construction and filling, medium-term impacts during dormant periods between CDF filling seasons and before final closure, and long-term impacts following final closure of the CDF.
- The Port shall evaluate the T4 CDF using the performance standards provided by USEPA. These performance standards may be considered just one facet of a

sensitivity analysis of the performance of various CDF designs, and the Port shall determine the feasibility and cost of a CDF design that fully achieves these performance standards. As necessary, the Port may need to adjust sediment acceptance criteria, CDF design criteria, or filling/operational parameters to demonstrate achievement of the USEPA performance standards.

In a letter dated February 5, 2010, the Port acknowledged USEPA's decision to set the final CDF design, construction, and cleanup effort at T4 until after the Harbor-wide ROD.

Since the February 5, 2010 letter, the following additional activities have occurred related to the T4 CDF 60 Percent Design:

- On February 18, 2010, USEPA provided the performance standards to the LWG and the Port for use in development and evaluation of CDF alternatives in the Harbor-wide FS (USEPA 2010a).
- The Port submitted the T4 CDF Groundwater Model Input Parameter Memorandum on April 1, 2010, and USEPA provided comments on April 19, 2010. On April 28, 2010, the Port, USEPA, and its federal, state, and tribal partners held a meeting to get further clarification of USEPA's CDF performance standards, and USEPA comments on the Groundwater Model Input Parameter Memorandum (see April 28 meeting minutes in Appendix A).
- The Port submitted the T4 CDF Long-Term Groundwater Modeling Results Memorandum on June 18, 2010. USEPA provided comments back to the Port on July 16, 2010. The Port and USEPA met on July 29, 2010 to discuss USEPA's comments on the memorandum and to obtain clarification on significant technical issues before moving forward with the T4 CDF 60 Percent Design. Meeting notes were prepared by the Port and approved by USEPA with few clarifications on August 4, 2010. On August 30, 2010, the Port provided written responses to USEPA comments on the memorandum, and on September 13, 2010, USEPA approved the Port's responses with few comments.

The Groundwater Model Input Parameter Memorandum, the Long-Term Groundwater Modeling Results Memorandum, USEPA comments on the two memoranda, USEPA-approved Port responses, and USEPA-approved meeting notes for April 28 and July 29, 2010 are provided in Appendix A.

Following the resolution of USEPA's comments on the T4 CDF Long-Term Groundwater Modeling Results Memorandum, and in accordance with the USEPA-approved schedule for submittal of the T4 CDF 60 Percent Design documents, the schedule of the documents was extended until October 5, 2010. The T4 CDF 60 Percent Design documents are the subject of this report. These documents are being submitted to USEPA and the LWG, and the information will be included in the Harbor-wide FS to evaluate sediment disposal options for the Portland Harbor remedial action. The T4 CDF 90 and 100 Percent Design documents and the additional T4 Phase II Removal Action activities will be developed after issuance of the Portland Harbor ROD.

1.2 Remedial Action Objectives

The Portland Harbor site Remedial Action Objectives (RAOs) are objectives that apply to all remedial action activities that occur within the Harbor. As such, these will also apply to the T4 CDF and are provided below for reference. The draft Portland Harbor RAOs listed below were provided by USEPA to the LWG on September 30, 2009 (USEPA 2009a); however, they are not final and are subject to refinement through the RI/FS process.

- **RAO 1: Reduce to acceptable levels human health risks from exposure to contaminated sediments[1] resulting from incidental ingestion of and dermal contact**

[1] Sediments are defined as soils, sand, organic matter, or minerals that accumulate on the river bottom. For purposes of describing the RAOs, sediment also includes the interstitial water and transition zone water (TZW) that is influenced by groundwater and surface water and thus can also be contaminated by groundwater, surface water, or chemicals dissolving off of the sediments. Sediments extend up to the ordinary high water mark (OHWM; 13.3 feet NAVD88) along the banks (including beach sediments) within the Portland Harbor Superfund Site. Riparian soils are found along the river banks from the OHWM to the mean high water mark (20 feet NAVD88). High water mark datum is from Proposed Round 3 Scope of Work, Portland Harbor Superfund Site, February 17, 2006.

with sediments, and comply with identified Applicable or Relevant and Appropriate Requirements (ARARs).

This RAO applies to direct human health sediment exposure scenarios found to have an unacceptable risk in the risk assessment. The goal for this RAO is to reduce risks to human health from chemicals of concern (COC) concentrations in contaminated sediments through sediment remedies at the site, comply with chemical-specific ARARs identified for the site, and protect beneficial uses of the Willamette River at the site.

- **RAO 2: Reduce to acceptable levels human health risks from indirect exposures to COCs through ingestion of fish and shellfish that occur via bioaccumulation pathways from sediment, and/or surface water and comply with identified ARARs.**

  This RAO applies to fish and shellfish consumption scenarios found to have an unacceptable risk in the risk assessment. The goal is to reduce risks to human health through sediment remedies that protect humans from indirect exposures to COCs through eating fish and shellfish exposed to COCs via bioaccumulation and bioconcentration, comply with chemical-specific ARARs identified for the site, and protect the beneficial uses of the Willamette River at the site. This RAO is expected to contribute to the reduction and elimination of Portland Harbor polychlorinated biphenyl (PCB) fish consumption advisories. It is recognized that reduction and elimination of the Portland Harbor fish advisory can only be achieved when conducted in conjunction with other Portland Harbor source controls and other PCB reduction efforts conducted under other regulations and programs within the Willamette River watershed.

- **RAO 3: Reduce risks from COCs in surface water at the site to acceptable exposure levels that are protective of human health risks from ingestion of, inhalation of, and**

dermal contact with surface water; protect the drinking water beneficial use of the Willamette River at the site; and comply with identified ARARs.

This RAO applies to direct human health surface water exposure scenarios found to have an unacceptable risk in the risk assessment and the protection of the drinking water beneficial use of the Willamette River. The goal is to reduce risks from COC concentrations in surface water, to the extent practicable, through sediment remedies that protect humans from the ingestion of and dermal contact with surface water; comply with chemical specific ARARs identified for the site; and protect the beneficial uses (domestic/private water supply) of the Willamette River at the site.

- **RAO – Human Health Groundwater: Reduce to acceptable levels human health risks resulting from direct exposure to contaminated groundwater and indirect exposure to contaminated groundwater through fish and shellfish consumption, and comply with identified ARARs.**

  This RAO applies to human health risks via exposure to contaminated groundwater plumes that exceed ARARs and indirect exposure to COCs in groundwater plumes discharging to the Willamette River found to have an unacceptable risk in the risk assessment based on fish and shellfish consumption with the understanding that groundwater plumes will be controlled to achieve ARARs and risk-based remediation goals through upland source control actions. The goal for this RAO is to reduce risks to human health from COC concentrations in contaminated groundwater through sediment remedies at the site, comply with chemical-specific ARARs identified for the site, and protect beneficial uses of groundwater and the Willamette River at the site. For groundwater plumes that are controlled through effective upland source control measures, this RAO would apply to groundwater plumes downgradient of the source control measure.

- **RAO 4: Reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated sediments and comply with identified ARARs.**

  This RAO applies to all ecological receptors found to have an unacceptable risk in the risk assessment via direct sediment exposure. The goal is to reduce risks to ecological receptors from COC concentrations in contaminated sediments and groundwater through sediment remedies at the site, prevent unacceptable effects on the survival, growth, and reproduction of ecological receptors at the site, and comply with chemical-specific ARARs identified for the site.

- **RAO 5: Reduce to acceptable levels risks to ecological receptors from indirect exposures through ingestion of prey to COCs in sediments via bioaccumulation pathways from sediment and/or surface water and comply with identified ARARs.**

  This RAO applies to all ecological receptors found to have an unacceptable risk in the risk assessment through ingestion of prey. The goal is to reduce risks from COCs through sediment remedies that protect ecological receptors from exposures to COCs through consumption of fish and shellfish, benthic organisms and other prey items exposed to COCs via bioaccumulation and bioconcentration; comply with chemical-specific ARARs identified for the site; and protect the beneficial uses of the Willamette River. This RAO is expected to contribute to reduction of prey ingestion related ecological risks through reduction in sediment chemical contributions to fish tissue. It is recognized that reduction of and elimination of these risks can only be achieved when conducted in conjunction with other Portland Harbor source control efforts conducted under other regulations and programs within the Willamette River watershed.

- **RAO 6: Reduce risks from COCs in surface water at the site to acceptable exposure levels that are protective of ecological receptors based on the ingestion of and direct contact with surface water and comply with identified ARARs.**

  This RAO applies to all ecological receptors found to have an unacceptable risk in the risk assessment through exposure to surface water. The goal is to reduce the risk from COC concentrations in surface, water to the extent practicable, through sediment remedies that prevent unacceptable effects on survival, growth, and reproduction of ecological receptors; comply with identified chemical-specific ARARs; and protect the beneficial uses of the Willamette River.

- **RAO – Ecological Groundwater: Reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated groundwater and indirect exposures through ingestion of prey via bioaccumulation pathways from groundwater, and comply with identified ARARs.**

  This RAO applies to all ecological receptors found to have an unacceptable risk in the risk assessment via exposure to contaminated groundwater plumes discharging to the Willamette River and through ingestion of prey with the understanding that groundwater plumes will be controlled to achieve ARARs and risk-based remediation goals through upland source control actions. The goal is to reduce risks to ecological receptors from COC concentrations in contaminated groundwater through sediment remedies at the site, prevent unacceptable effects on the survival, growth, and reproduction of ecological receptors at the site, and comply with chemical-specific ARARs identified for the site. For groundwater plumes that are controlled through effective upland source control measures, this RAO would apply to groundwater plumes downgradient of the source control measure.

1.3 Description and Organization of this Document

The T4 CDF 60 Percent Design progresses the project details from the Conceptual Design in terms of refining CDF dredging and filling areas and volumes; selecting construction processes, technology, and equipment where appropriate; identifying material borrow sources; and other project details. The T4 CDF 60 Percent Design involves the preparation of design calculations and analyses to work out design details, the preparation of design drawings and specifications, and the establishment of quality control (QC) and monitoring procedures that will be used to verify that USEPA performance standards have been met.

The CDF 60 Percent Design deliverables provided in this document and related appendices include the following information:

- Design Analysis Report (DAR) providing the design criteria and basis of design for the CDF, including technical parameters and supporting calculations upon which the design will be based including, but not limited to, design requirements for the development of the CDF
- Construction documents and schedule including Drawings (Appendix B) and Construction Specifications (Appendix C)
- Design plans including a Draft Construction Quality Assurance Plan (CQAP) detailing the CDF construction verification methods and approach to quality assurance (QA) during construction (Appendix D); and a Draft Water Quality Monitoring Plan (WQMP) detailing the water quality monitoring approach (Appendix E)

The remainder of this document provides detailed information on the development of the T4 CDF 60 Percent Design as follows:

- **Section 2 – Confined Disposal Facility Description** provides a general overview of the CDF setting, performance standards, construction activities, and monitoring activities.
- **Section 3 – Existing Conditions** summarizes the information and data collected within the CDF area that will be used as the basis of the design, including physical conditions, hydrogeologic and geotechnical conditions, hydrodynamic characteristics, sediment quality, and former and current site uses.

- **Section 4 – Dredge Plan** provides the conceptual dredge plan for excavating the berm key area of the CDF, including the design approach, dredge design surface, neatline dredge prism, volumes, and equipment selection.
- **Section 5 – Confined Disposal Facility Design** provides the conceptual CDF design including the basis for design, design approach, containment berm stability, containment berm erosion resistance, consolidation and settlement, CDF cover layer, CDF filling procedures, assessment of potential impacts on Willamette River flood stage, demolition of Slip 1 structures, outfall and stormwater rerouting, waterfront structures and berth replacement, volumes (capacity), and equipment selection.
- **Section 6 – Water Quality** discusses water quality criteria, contaminant mobility testing, and predicted water quality associated with the construction and long-term operation of the CDF, including analysis of both short-term and long-term effects.
- **Section 7 – Habitat Mitigation** generally describes the habitat mitigation components and design process.
- **Section 8 – Applicable or Relevant and Appropriate Requirements** discusses the regulatory requirements that must be achieved during CDF construction and operation.
- **Section 9 – Construction Schedule and Sequencing** describes the duration and order of the CDF construction activities.
- **Section 10 – Engineering Cost Estimate** provides anticipated costs to build the T4 CDF, including direct and indirect construction costs, habitat mitigation, and long-term monitoring.
- **Section 11 – Access and Easement Requirements** provide access and easement information related to construction of the CDF.
- **Section 12 – Institutional Controls** details the actions required to maintain the CDF.
- **Section 13 – References** summarizes the references used in the document.

The appendices provide the following information:

- Appendix A—Contaminant Transport Modeling of the CDF
- Appendix B—Drawings
- Appendix C—Construction Specifications

- Appendix D—Construction Quality Assurance Plan
- Appendix E—Water Quality Monitoring Plan
- Appendix F—River Current Analysis
- Appendix G—Berm Armor Design
- Appendix H—Geotechnical Assessment of the Containment Berm
- Appendix I—Flood Analysis
- Appendix J—Confined Disposal Sediment Management Plan
- Appendix K—Long-term Monitoring and Reporting Plan (Outline)
- Appendix L—Engineering Cost Estimate

2 CONFINED DISPOSAL FACILITY DESCRIPTION

2.1 T4 CDF Project Area

The Port is a port district of the State of Oregon, which owns the T4 uplands between River Miles (RMs) 4.1 and 4.5 on the Lower Willamette River at 11040 North Lombard, Portland, Multnomah County, Oregon. The Port also owns a portion of the submersible and submerged lands in Slip 1 within the CDF project area. The remainder of the submersible or submerged land is owned by the State of Oregon and managed by the State of Oregon Department of State Lands (DSL). The Port has been, and will continue to be, in discussions with DSL as the CDF design progresses to acquire the remaining submersible land from DSL that is necessary to implement the project.

A vicinity map and site plan showing the T4 CDF project area is provided in Figure 1-1.

2.2 Overview of CDF Elements

An at-grade CDF having a footprint of approximately 14 acres will be constructed in T4 Slip 1. Sediments to be placed in the CDF will include sediments over-excavated from the berm key area of Slip 1, dredged sediments from T4 Slip 3, and dredged sediment from other Areas of Potential Concern (AOPCs) in the Portland Harbor Superfund Site. Groundwater modeling results show that sediments from ten high-priority AOPCs in Portland Harbor would be suitable for placement in the T4 CDF (see Appendix A), thus validating the overall effectiveness and applicability of the facility for confining Portland Harbor dredged sediment. The AOPCs that would be suitable for placement in the T4 CDF include potential dredge prisms adjacent to Evraz Oregon Steel, Schnitzer, T4, BP-Arco, Mar-Com Marine, Willamette Cove, Cascade General Shipyard, Swan Island Lagoon, Gunderson, and Fireboat Cove, although estimated dredge volumes have not yet been developed for these sites. However, the CDF must be selected as an appropriate disposal site through the Portland Harbor ROD.

By constructing the CDF to an at-grade surface, the newly gained land can be used for water-dependent commercial purposes. A containment berm will be constructed at the mouth of

Slip 1 to serve as an isolation/retention structure for the dredged sediment. The Port is planning to acquire State of Oregon property for the purpose of constructing the CDF. Section 5 provides more details on the conceptual design of the CDF. The construction elements of the CDF are shown in plan view and in cross-section on Figures 5-1 and 5-2, respectively.

2.3 Overview of CDF Construction Sequencing

Construction of the T4 CDF will be completed in three main stages as summarized below:

- **Stage 1** – Construction of the CDF containment berm.
- **Stage 2** – Filling of the CDF with contaminated sediments from Portland Harbor AOPCs.
- **Stage 3** – Completion of the CDF cover.

The preparation, berm construction, filling, and covering of the CDF is expected to take approximately 7 to 10 years to complete, depending on the schedule of Harbor-wide remedial actions and the availability of suitable dredged material. In-water construction work will adhere to the timing restrictions specified by the Oregon Department of Fish and Wildlife (ODFW; 2000) for the Lower Willamette River, specifically, the late summer and fall in-water work window from July 1 to October 31. After the berm is built and Slip 1 is isolated from the river, work in the CDF will not be bound by these in-water construction windows.

2.3.1 Stage 1 – CDF Preparation and Containment Berm Construction

This stage of the project will occur over a 2-year period and includes the following construction elements:

Slip 1 Preparation. In order to create a CDF in Slip 1, a number of structures need to be demolished and/or relocated. The Slip 1 piers, including Berths 405 and 408, will be demolished using predominantly water-based equipment, with some support from upland equipment. Because work will be conducted from the water, the construction of the containment berm cannot begin until the demolition is completed. Berth 405 will be replaced with a replacement berth near the containment berm. The footprint of the new pier is offset from the berm footprint, so work on the two structures can occur concurrently.

Stormwater Outfall Rerouting. Another element of preparing Slip 1 for filling is the relocation of the stormwater outfalls. Four Port outfalls and one City of Portland (City) outfall are known to discharge into Slip 1. The majority of the work will occur out of water, so it can be completed outside the in-water work window. However, the daylighting of the outfalls into the Willamette River is in-water work that must be completed during the in-water work window.

Containment Berm Construction. The first task related to containment berm construction is overexcavation of the soft sediments below the berm. Removal of approximately 25,000 cubic yards (cy) of sediment will be completed with an 8-cy clamshell bucket and bottom-dump barge; the overexcavated material will be placed in the head of Slip 1. The overexcavation will then be backfilled with select fill. Once the overexcavation is filled to grade, the contractor will start placement of training terraces using either an 8-cy clamshell bucket or a skip box. Once the terraces are constructed on each side of the berm, select fill will be placed in between using a bottom-dump barge. The containment berm will require approximately 290,000 tons of select fill and 95,000 tons of rock for training terraces. The lower portion of the berm will be constructed from the water during the in-water work window; however, after the berm breaches the water surface, the upper portion will be finished in the dry with upland-based equipment.

2.3.2 Stage 2 – Filling the CDF with Portland Harbor Sediments

The CDF can confine an estimated 670,000 cy of contaminated sediments. Additional material (200,000 to 300,000 cy) beyond that volume may also be placed in confinement depending on the amount of settlement that occurs. The offloading facility is expected to be located at the replacement berth, and would likely be sized to offload 2,000 to 4,000 cy per day assuming a 10- to 12-inch-diameter hydraulic dredge pump, respectively. Assuming there are 100 working days per in-water work season (6 days per week between July 1 and

October 31), the maximum quantity of material that could reasonably be offloaded would be 200,000 to 400,000 cy. As a result, the filling process is estimated to take up to 4 years to complete, although it could take longer or shorter depending on the schedule of the Harbor-wide remedial actions and the availability of suitable dredged material.

2.3.3 Stage 3 – Placement of the CDF Cover

The CDF cover consists of two layers. The lower layer, located directly above the confined dredged sediment, is the import fill layer. The volume of this layer is approximately 464,000 cy. The majority of this material is anticipated to be suitable dredged material brought to the site on haul barges, and offloaded as described in the previous section. As with the contaminated sediment, the rate of placement of the import fill layer will be a function of the supply rate. At a minimum, the filling would require one to two seasons to complete.

The top of the CDF is the CDF cover layer. This layer consists of approximately 272,000 tons of aggregate. This material will be from an upland source, brought to the site by truck and/or barge, and offloaded. It is anticipated that offloading by barge would be done mechanically. The fastest rate that this material could be placed is estimated at 2,000 tons per day. The filling could be completed at any time during the year since it does not involve in-water work. This layer would require 6 to 12 months to construct. In all, placement of the CDF cover material is expected to take 1 to 2 years to complete.

2.4 Overview of CDF Monitoring Activities

Throughout this document and the appendices there are numerous sampling and monitoring requirements both for short-term activities associated with CDF construction and filling, and long-term activities associated with the operation and maintenance of the CDF after it has been filled and closed. Short-term monitoring activities will be used to verify that construction measures are in compliance with CDF design specifications, short-term performance objectives, and water quality ARARs, and are protective of archeologically sensitive areas. Long-term monitoring activities will be used to verify that the T4 CDF is performing as intended, and that the long-term performance objectives and water quality

ARARs are being met. Table 2-1 summarizes the various CDF monitoring requirements, with references to other parts of the CDF design documents where more details can be found.

2.5 Project Performance Standards

The performance standards used to guide the design of the T4 CDF and develop the attendant construction verification and monitoring plans are described in Section 4 (Dredge Plan) and Section 5 (Confined Disposal Facility Design). The current status of ARARs related to the construction and operation of the CDF are summarized in Section 8. However, the final ARARs will be established for the Portland Harbor Superfund Site in the ROD. As a result, the CDF performance standards may be modified by USEPA during the FS and ROD processes. Any such modifications would be accommodated in the later phases of design after the ROD is issued.

3 EXISTING CONDITIONS

Existing conditions in the vicinity of T4, and specifically in Slip 1, were used to inform the CDF design. The primary information describing the existing conditions is the data collected as part of the *Terminal 4 Early Action Engineering Evaluation/Cost Analysis* (BBL 2005), as summarized in the T4 Characterization Report (BBL 2004a), supplemented with additional pre-construction data (see Section 3.6). This information includes data on site use; physical, hydrodynamic, wind, and geotechnical conditions; sediment quality; and other design considerations. The information on existing site conditions, along with how the site is currently used by the Port and its tenants, are important considerations that were factored into the CDF design.

It should be noted that the design and implementation of the Port's Phase I Removal Action in 2008 represents a changed condition at T4 since the EE/CA (BBL 2005) and the Action Memo (USEPA 2006a) were issued. During the Phase I Removal Action, dredging and off-site disposal of contaminated sediment occurred at three areas exhibiting some of the highest chemical concentrations at T4 (including areas adjacent to Berth 411 and Pier 5 in Slip 3, and an area north of Berth 414 near the mouth of Slip 3), and a fourth area was dredged for navigational purposes (adjacent to Berth 410 in Slip 3) (see Section 1.1). In all, nearly 13,000 cy of sediments were removed (Anchor QEA 2009). As a result, the volume and average concentration of contaminated dredged material from T4 that would be placed in the CDF has been reduced, providing additional capacity for dredged material from other sites in Portland Harbor.

3.1 Terminal 4 Physical Characteristics

The T4 uplands comprise about 283 acres (Port of Portland 2002), including the Toyota lease areas, and are generally flat in grade in proximity to the slips. The surface covering is primarily asphalt, with minor areas of gravel and/or ballast associated with the rail lines. The submerged portion of T4 is approximately 38 acres, of which Slip 1, Slip 3, and Wheeler Bay make up about 28 acres; and the area from the mouths of the slips to the Harbor Line comprises an additional 10 acres.

The elevation of T4 generally ranges from 30 to 35 feet mean sea level (MSL) in proximity to the slips (see Figure 1-3). The river stage (i.e., elevation) is typically between 3.7 and 11.7 feet NGVD (also MSL), although higher levels occur during seasonal peak discharges. This range is based on information from the U.S. Geological Survey (USGS) gage at the Morrison Street Bridge at RM 12.8, approximately 8.5 miles upstream from T4. The gage readings at the Morrison Street Bridge are considered representative of the river levels at T4 because the minor tributary inputs between the gage and the site, primarily small seasonal creeks and municipal stormwater outfalls, are negligible compared to the flow in the river (BES 2008), and the Columbia River Datum is only 0.2 feet higher at the upstream gage compared to T4. The diurnal tidal range in the St. Johns area is 2.2 feet at low river stages, and becomes progressively less with higher river stages (USGS 2006).

To the northeast of T4, the topography is slightly sloping, but somewhat variable, rising gradually to about 50 feet MSL. Southeast of T4, the ground surface rises at 5 horizontal to 1 vertical (5H:1V) or shallower to an elevation of about 100 feet MSL, corresponding to the St. Johns area of Portland. To the west of T4, on the opposite bank of the Willamette River channel, are the Tualatin Mountains (Portland Hills), rising relatively steeply at about 1.5H:1V to 3.5H:1V to an elevation of about 1,000 feet MSL.

3.1.1 Slip 1 Physical Characteristics

Slip 1 is approximately 13 acres and is currently underutilized. The mudline elevation in Slip 1 ranges from about -32.3 to -36.3 feet NGVD according to the most recent annual bathymetric condition survey by the Port (see Figure 1-3).

Two large piers exist within Slip 1, from the head of the slip to about the midpoint, on the north and south sides, forming Berths 405 and 408, respectively. The piers are timber-pile supported with concrete columns and interconnecting concrete framework built from about the shoreline and above as the support structure for the pier deck and associated structures. The former grain elevator is located to the north of Slip 1.

Where it is not covered by the pier structures described above, the shoreline conditions in most of the Slip 1 area are either steeply sloped or armored with large riprap. The embankment slope west of the existing pier at Berth 408 does not have slope protection and is showing signs of erosion in the form of scarps and surficial sloughing. Factors that contribute to the erosion of this bank likely include undercutting associated with propeller wash during former uses of the pier, impacts from surface currents and wind waves, and possibly cycles of soil wetting and drying associated with tidal and seasonal variations in river stage combined with the relatively steep slope.

Underpier slopes generally range from 2H:1V to 3H:1V, with the exception of slopes near Berth 408, which range up to 1H:1V (Port of Portland 2002).

3.2 Terminal 4 Hydrodynamic Characteristics

This section summarizes the hydrodynamic characteristics of T4. These characteristics will be used for sizing armor material to prevent erosion of the berm face, and for evaluating potential water quality impacts during dredging of the berm key. The hydrodynamic characteristics of T4 were measured during the EE/CA and summarized in BBL (2004b). It should be noted that data gathered during the EE/CA are mainly representative of seasonal low-flow and low-rainfall conditions. The general hydrodynamic conditions are as follows:

- Hydrodynamics within Slip 1 are affected by variations in river flow, river stage, ship-induced currents, and, to a lesser extent, localized currents from stormwater discharges. In general, given the orientation of the slip relative to the river, river-induced currents in the slip are attenuated (i.e., reduced velocity) compared to the currents in the mainstem of the river.
- Although river-induced currents have an influence on the hydrodynamics at T4, current velocities in a many areas, especially Slip 3, are dominated by propeller-induced currents. In response to the higher current velocities, propeller-induced currents may cause increased turbidity levels and more active sediment transport.
- Ongoing river-induced sedimentation occurs throughout much of the T4 area. Sedimentation rates in areas of the terminal that are removed from active ship traffic

range from 0.6 centimeters per year (cm/yr) in Wheeler Bay to 2.5 cm/yr in Slip 1 (Formation Environmental 2010). In Slip 3, propwash from marine vessels creates localized areas of erosion beneath the active berths, causing resuspension and redistribution of sediment.

Appendices F and G provide more information on hydrodynamic conditions.

3.3 Wind Conditions

Wind data was obtained for the Portland International Airport from the National Climatic Data Center (1976 to 2004) and the Meteorological Resource Center (Webmet.com; 1961 to 1975). Appendix G provides more information on wind data, which was used to determine the appropriate size of material to use as protective armor on the CDF berm.

3.4 Slip 1 Geotechnical Conditions

Geotechnical information was used for various components of the CDF design, in particular, to assess the short-term and long-term stability of the berm, and the stability of shoreline structures near to which dredging will occur.

Subsurface geotechnical conditions in Slip 1 are important to the design process because the CDF berm must be geotechnically stable (i.e., will not subside, slough, or fail under ambient and or earthquake conditions). Therefore, the contents of 24 geotechnical reports prepared for past projects within T4 were reviewed. These data were screened for applicability to the project relative to proximity and exploration methodology. Over 80 borings and 10 cone penetrometer tests (CPTs) were included in this review. Of the borings reviewed, 11 were found to have been advanced within the general CDF area and completed with modern drilling equipment. The most significant data available from the borings consisted of standard penetration test (SPT) blowcounts. The SPT test results were summarized and corrected for rod length, overburden pressure, and hammer efficiency. For all corrections, mid-range values as recommended by the Federal Highway Administration were utilized. SPT results provide a measure of the density or strength of the sediment.

The following soil units were encountered in the geotechnical explorations:

- **Loose to Medium Dense Sand Fill.** In general, the upland areas adjacent to the CDF were constructed of loose to medium dense sand fills. The thickness of the fill layer ranges from approximately 17 to 35 feet. Gradation testing of the sand fills indicates fines content ranging from approximately 5 to 15 percent.
- **Soft Surface Sediments.** The floor of Slip 1 is covered by soft clayey, silty, and sandy sediments. Based on the sediment cores completed for the EE/CA (BBL 2005), the soft sediment layer generally ranges from about 0 to 3 feet in thickness.
- **Sand.** The majority of Slip 1 is underlain by a dark grey, medium dense to dense, medium to coarse sand. This sand is consistent with Willamette River alluvium. Based on past laboratory testing, the fines content of this sand ranges from 3 to 8 percent. The upper 5 to 10 feet of this formation can be disturbed and loose, likely owing to ongoing alluvial processes. Below this disturbed material, the density of the sand is relatively uniform. Based on a review of 138 corrected SPT values, the average blowcount value in this formation was 21 blows per foot (bpf) with a standard deviation of 9.3 bpf. The distribution of blowcounts indicates little to no variation with depth. Only one SPT sample had a measured blowcount of less than 10 (indicative of loose sand), and seven samples had blowcounts of more than 30 (indicative of dense sand). With little variation, this formation can be modeled as a medium dense, relatively clean sand.
- **Troutdale Gravel.** Dense, partially cemented deposits of gravel and sand were encountered at depth below the alluvial sands. This deposit likely consists of the Troutdale Formation.

Soil unit information was used to develop site models for both geotechnical stability of the berm and groundwater contaminant transport through the CDF.

3.5 Slip 1 Hydrogeologic Conditions

A summary of hydrogeologic conditions in Slip 1 is provided below. This information was used as the basis for the groundwater contaminant transport analysis of the CDF (see Appendix A).

After the CDF is constructed and filled, groundwater will flow through and around the facility toward the Willamette River. The groundwater pathway must be characterized to determine whether any of the contaminants in the contained dredged material will be transported to the Willamette River at levels of concern. A conceptual site model of the groundwater flow system was developed based on the hydrogeologic conditions at T4, and this formed the basis of the of groundwater contaminant transport model (see Appendix A).

The hydrogeology of T4 is summarized in Appendix D of the EE/CA report (BBL 2005), and presented in greater detail in the T4 Characterization Report (BBL 2004a). BBL (2005) summarized the geologic stratigraphy adjacent to and beneath the proposed CDF. The stratigraphy consists of the following:

- **Upland Fill Material**, consisting of medium to fine sand ranging in thickness from about 5 to 40 feet.
- **Unconsolidated Alluvial Deposits**, consisting of fine sand west of the former shoreline and interbedded layers of gravel, sand, silt, and clay to the east of the former shoreline, ranging in thickness from 120 to 160 feet
- **Troutdale Gravel**, encountered at an elevation of approximately -112 to -166 feet NGVD.

The groundwater flow direction is toward the Willamette River. In nearshore locations, groundwater in the upland fill material, unconsolidated alluvial deposits, and Troutdale Gravel is in direct hydraulic connection with the river. As a result, groundwater elevations respond rapidly to changes in river stage.

3.5.1 Boring and Well Inventory in Site Vicinity

A records review was conducted to inventory groundwater wells within a half mile of the CDF and water supply wells within one mile of the CDF. The results are compiled in Table 3-1 and Figure 3-1. No municipal water supply wells were identified in the search radius.

Well records were reviewed on the Oregon Water Resources Department web page at http://apps.wrd.state.or.us/apps/gw/well_log/ for wells located in Township 1N, Range 1W, Sections 1 and 2 and Township 2N, Range 1W, Sections 35 and 36. The resulting well list was reduced by all wells with records of abandonment, locations listed as geotechnical borings, wells located across the Willamette River, and wells outside the search radius described above. A total of 164 wells were identified. Most wells are monitoring wells associated with industrial properties, including records of 71 wells at T4. Four wells listed as "domestic/irrigation" wells were identified within a 1-mile radius; however, these wells were installed in 1944 when the property was agricultural. The property has since been redeveloped as industrial. Although there is no record of abandonment, these wells are likely no longer in use. The use of the remaining industrial supply wells is unknown.

3.5.2 Upgradient Groundwater Quality

Groundwater quality upgradient of the CDF was evaluated to determine whether existing site contamination could affect the quality of groundwater migrating through the CDF. A comprehensive investigation of groundwater quality was conducted as part of the Terminal 4 Slip 1 Remediation Investigation (ACA and NewFields 2007; Formation Environmental 2010). Chemical analytical results from seven monitoring wells surrounding Slip 1 and within 200 feet of the slip shoreline were reviewed (including wells MW-03, -08, -09, -10, -11, -12, and -26; see ACA and NewFields 2007). The wells were analyzed for metals, polycyclic aromatic hydrocarbons (PAHs), and PCBs, and screened against the water quality criteria in Table 6-1. Four rounds of data were collected at most wells.

In general, no groundwater plumes were identified on the uplands. No PCBs were detected in any of the Slip 1 monitoring wells at any time. PAHs were infrequently detected in Slip 1 shoreline wells at estimated concentrations below the laboratory reporting limit (0.02 micrograms per liter [µg/L]). All of the detected PAH concentrations were below fish consumption, drinking water, and aquatic life criteria. Total concentrations of CDF target metals (cadmium, copper, lead, and zinc) were at or near background concentrations and below drinking water MCLs, as appropriate. All dissolved metals concentrations were well below their respective aquatic life criteria.

Based on these data, upgradient groundwater is not expected to significantly affect the quality of groundwater in the T4 CDF. The Terminal 4 Sediment Recontamination Analysis Approach reached a similar conclusion: "*The groundwater monitoring results, screening evaluation of the data obtained, and a "weight of evidence" evaluation support that there are no COI at the Facility at concentrations that could cause significant, if any, degradation of water in the river or slips or pose unacceptable risk to human health from fish consumption*" (Formation Environmental 2010).

3.6 Slip 1 Sediment Chemistry and Physical Properties Data

A number of sources of sediment chemistry data for T4 are available from previous investigations. The Port has been investigating the nature and extent of sediment contamination at T4 since before 1988. Other organizations, including the U.S. Army Corps of Engineers (USACE), USEPA, and ODEQ, have investigated the nature and extent of sediment contamination in the Willamette River and have collected sediment samples in the vicinity of T4 as part of their investigations (BBL 2004a). More recently, sediment chemistry data were collected as part of the T4 EE/CA (BBL 2005).

The EE/CA is the primary source of sediment chemistry data for the CDF design (BBL 2005). Other historical reports containing sediment chemistry data with acceptable quality and documentation in the Slip 1 area include:

- USEPA Portland Harbor Sediment Investigation Report (Weston 1998)
- Willamette River Channel Maintenance Characterization Study (USACE 1999)

Sediment quality data as it pertains to construction of the T4 CDF is evaluated in Section 6.2.1, and a brief summary of that data is presented here. Refer to Table 6-3 for a statistical summary of sediment analytical results in the berm key dredge area and in the Slip 3 removal areas (including the Phase I removal area, which was dredged and disposed offsite in 2008, and the Phase II removal area, which is proposed for placement in the T4 CDF).

In Table 6-3, the average concentrations in the various remediation areas are compared to threshold effects concentrations (TEC values) and probable effects concentrations (PEC values) from MacDonald et al. (2000). In the berm key dredge area, metals, DDx, and PCB concentrations are near or below the TEC values, and PAHs are between the TEC and PEC values, indicating this to be a relatively low risk area. In the Slip 3 removal areas, the average lead and PAH concentrations are above the PEC values, and the other metals, pesticides, and PCB concentrations are between the TEC and PEC values. This material is suitable for placement in the T4 CDF, as discussed in Appendix A, Attachment 1 to the Groundwater Model Input Parameter Memorandum.

3.7 Site Uses

3.7.1 Terminal 4 Tenants and Adjacent Properties

The history of the T4 area and historical tenant operations are described in detail in the EE/CA Work Plan (BBL 2004b) and in Appendix A of the EE/CA (BBL 2005). Appendix A of the EE/CA provides a chronology of facility development between 1906 and 1999, a chronology of dredging and filling activity between 1917 and 2003, and a detailed description of T4 operations beginning in 1917.

Current tenants at T4 near Slip 1 and Slip 3 are Cereal Food Processors, International Raw Materials (IRM), Rogers Terminal, Kinder Morgan Bulk Terminals (KMBT), and Union Pacific Railroad. Adjacent property owners include Schnitzer Steel Industries, Northwest Pipe and Casing, and Burgard Industrial Park (housing both Boydstun Metal Works and Western Machine Works), all of which are under Voluntary Cleanup Program Agreements with ODEQ for remedial investigations of those properties. Toyota leases land from the Port on the southern portion of T4 facility adjacent to Berth 414.

At this time, the only active tenant operating within Slip 1 is IRM. Currently, IRM imports liquid bulk materials at Berth 408. Both barges and ships call on the berth. Vessel calls are very infrequent, typically less than once per month.

Berth 401 is currently inactive; however, IRM is planning to relocate its operations to that berth, allowing Berth 408 to be shut down prior to CDF construction. Potentially, other tenants may also start operating at Berth 401 during the timeframe of this project.

It is important to consider site uses during the design process to ensure that the impact of CDF construction activities on existing tenants will be minimized, and the CDF construction will not be compromised by other ongoing site operations.

3.7.2 Typical Vessels that Call at Terminal 4

Local pilots were contacted to determine typical operational conditions at T4. Commercial vessels that call on Berth 411 in Slip 3 are "Panamax" size, deep-draft Bulk Carrier (primarily grain) ships. While Berth 401 is not currently in operation, future operations at the berth are likely to include similar vessels that call on Berth 411 in Slip 3. These vessels are assisted in and out of port by large, privately-owned tractor tugs. Appendix G provides more information on vessels that call on the site and their characteristics.

4 DREDGE PLAN

Dredging is the physical removal of sediments from a specific area. As part of the CDF construction, dredging is required beneath the containment berm to remove soft sediment that may compromise the stability of the berm if it was left in place. The depth of removal beneath the berm is governed by geotechnical conditions rather than sediment concentrations.

4.1 Basis of Design

The dredge design objectives were developed in consideration of the dredging performance standards described below.

4.1.1 Dredging Performance Standards

The performance standards for dredging include:

- Performing the dredging in a manner that minimizes, to the extent practicable, water quality exceedances of field parameters (turbidity, dissolved oxygen [DO], pH, and temperature), and contingent chemical parameters outside the compliance boundary.
- Dredging and disposing of sediments in a manner that minimizes dredging residuals and prevents recontamination of adjacent sediments.
- Dredging to a depth that provides a competent foundation to support construction of a stable CDF berm.

4.1.2 Dredge Design Objectives

The following dredge design objectives were used to develop the dredge plan:

- **Minimize water quality impacts outside of the construction zone.** The need to meet water quality standards and compliance criteria factored into the selection of dredging methods. Water quality monitoring activities, standards, and criteria for dredging are described in detail in the WQMP (Appendix E). The dredging of material in the berm key area must meet, to the extent practicable, the water quality standards and criteria defined in the WQMP and the forthcoming USEPA Water

Quality Monitoring and Compliance Conditions Plan (WQMCCP) that will be issued for this work.

- **Provide a competent substrate to support a stable CDF berm.** Dredging beneath the CDF containment berm must be performed to remove soft and loose surficial sediment that might otherwise compromise the stability of the berm. The dredging will expose more competent subsurface material that provides a stronger foundation on which to build the berm.

4.1.3 Additional Considerations

Additional considerations that helped guide the development of the dredge plan included the following:

- Physical characteristics of the site, including dredging in 30- to greater than 50-foot water depths
- The need to minimize disruption to the Port's tenant operations at T4
- The need for dredging technology to be compatible with the CDF such that dredged material removed from the berm key can be placed into the head of Slip 1 prior to filling the CDF with other material from Portland Harbor

The remainder of this section describes the detailed development of the dredge prism.

4.2 Dredge Design

The berm key dredge plan (as shown on Figure 4-1) was developed to remove soft sediment that may compromise the stability of the berm. The target dredge depths were developed to remove these soft sediments and, after factoring in engineering considerations and overdredge allowance, the dredge target depth includes a majority of the soft sediments.

4.2.1 Volume

The neatline dredge prism volume was calculated. Because of dredging limitations, the actual volume dredged will be somewhat higher than this neatline volume. The allowable overdredge volume was computed by taking the spatial footprint of the dredge prism and multiplying that area by a 12-inch allowable overdepth.

The neatline dredging volume for the area beneath the containment berm is approximately 33,000 cy. The 12-inch allowable overdepth volume is approximately 6,000 cy, for a total approximate dredging volume of 39,000 cy.

4.2.2 Equipment Selection

The selection of appropriate dredging equipment is necessary to balance effectiveness, engineering feasibility (given site constraints; e.g., material density, proximity to structures, and potential for encountering dredging obstructions such as debris, rock, logs, pilings, etc.), potential for environmental impacts, potential for impacts to Port/tenant operations, cost, and scheduling. Some of the primary issues considered when selecting appropriate equipment included:

- Availability and types of equipment
- Maximizing environmental effectiveness
- Production rate capability
- Maintaining navigation access
- Minimizing disruption of Port/tenant operations
- Water depths
- Thickness of dredge prism
- Geotechnical properties of sediment targeted for removal and underlying materials
- River currents and tides
- Presence of significant debris
- Minimizing short-term water quality impacts
- Proximity to structures
- Accessibility of equipment

Mechanical dredging will be used for the berm overexcavation. An 8-cy clamshell bucket is anticipated for mechanical dredging (input from the contractor is required before making the final equipment selection). Use of an "open-dredge" clamshell bucket is supported by T4 dredging elutriate test (DRET) results, as well as the Phase I water quality monitoring results which indicate water quality effects from dredging the berm key are expected to be negligible (see also Section 6.2.1). Therefore, use of a "closed" environmental bucket is not expected to be necessary, although it is listed as a potential best management practice (BMP) in the WQMP (Appendix E). During the Phase I work, an environmental bucket had limited success dredging the more dense and sandy material due to its lighter weight.

Material from the excavation of the berm key will be placed at the head of Slip 1 (see Figure 4-1).

4.2.3 Overdredge Allowance

Depth control with dredging equipment has certain tolerances. To improve the reliability of achieving the design depths, an overdredge allowance is commonly given to the contractor. The contractor is paid for this allowance, but not for material removed below this allowance. A 1-foot overdredge allowance will be specified for berm overexcavation.

4.2.4 Construction Quality Control Related to Dredging

The CQAP (Appendix D) describes in detail the measures that will be implemented during construction to ensure that the design objectives of dredging are met and the performance standards are achieved. There are two specific QC measures that will be implemented to ensure that the dredge design is completed to meet the design objectives:

1. Achieving the specified dredging depths and lateral extents
2. Meeting water quality monitoring standards outside of the construction zone

Each of these measures is described in more detail below:

- **Achieve specified dredging depths and lateral extents.** Confirmation must be obtained that the sediments were removed to the target elevations and full lateral extents as depicted on the Drawings (Appendix B) and Construction Specifications (Appendix C). This will be accomplished by completing post-dredge hydrographic surveys of the berm key area and comparing them to the dredge plan. Any high areas above the target elevations in the dredge plan will be re-dredged by the contractor.

- **Meet water quality monitoring standards outside of the construction zone.** To ensure compliance with water quality criteria outside of the construction zone, monitoring of conventional field parameters (turbidity, DO, pH, and temperature) and contingent laboratory parameters (total suspended solids [TSS] and target chemical analytes) will be performed during dredging activities as described in the WQMP (Appendix E). Exceedances of water quality standards and criteria will trigger the implementation of additional BMPs (e.g., operational or engineering controls) to mitigate the water quality impacts of the dredging activities.

4.3 Dredged Material Placement

Sediment dredged from the berm key will be placed in the head of Slip 1 prior to construction of the berm at the mouth of the slip. As described in Section 4.2, approximately 39,000 cy of material will be dredged and placed on bottom-dump barges. The capacity of the haul barges will be 1,000 to 2,000 cy. After the barge is loaded, it will then be moved to the head of the slip for open-water placement of this material. In consideration of sediment quality in the berm key dredge area, dredging elutriate testing of T4 sediments, and Phase I water quality monitoring results, it is expected that turbidity will be the primary water quality concern during open-water placement (see Section 6.2.1). Water quality monitoring of open-water placement activities will be conducted in accordance with the to-be-developed USEPA WQMCCP for this project.

5 CONFINED DISPOSAL FACILITY DESIGN

As described in the EE/CA (BBL 2005), a CDF is an engineered structure for permanently containing dredged material in a nearshore environment. Confinement berms or dikes enclose the disposal area below the surface of the adjacent surface waters, thereby isolating the dredged sediment from adjacent waters. Confined disposal in a CDF is a proven technology that isolates contaminants from the aquatic environment and ensures protection of human health and the environment. Over the last 20 years, CDFs have been successfully designed and constructed at many other Superfund sites around the country and within USEPA Region 10. The remainder of this section describes the design basis and specific design information for constructing a CDF in Slip 1 at T4.

5.1 Basis of Design

The EE/CA (BBL 2005) and Action Memo (USEPA 2006a) established the approach of building a CDF at T4 with a permeable berm, consistent with other operating CDF designs in USEPA Region 10. The CDF design was conducted according to guidance procedures contained in USACE's Confined Disposal of Dredged Material manual (USACE 1987) and procedures followed for the CDFs constructed in St. Paul Waterway (City of Tacoma 2003) and Port of Tacoma Slip 1 (Occidental Chemical and Port of Tacoma 2003), both located in USEPA Region 10. As described for the development of the dredge prism, the basis of the CDF design relates to performance standards and design objectives and related criteria. As described below, these elements were used to guide the design of the CDF. A layout of the CDF that will be constructed in Slip 1 is shown on Figure 5-1.

5.1.1 CDF Performance Standards

On February 18, 2010, USEPA provided the LWG and the Port with a set of performance standards to be used in evaluating all CDF alternatives in the Harbor-wide FS, including the T4 CDF (USEPA 2010a). The intent of the USEPA CDF performance standards and further details regarding their implementation were clarified in subsequent correspondence between the LWG and USEPA (LWG 2010a and 2010b), as well as in notes from the April 28, 2010 meeting of the Port, USEPA, and its partners. The complete list of USEPA CDF performance standards and all related clarifying documents are provided in Appendix A.

The USEPA-directed performance standards will be met with the T4 CDF design presented in this DAR. Table 5-1 provides a list of USEPA CDF performance standards with an index of references to specific sections of the DAR in which those standards are addressed. Some of the key requirements of the USEPA CDF performance standards are summarized below.

- The CDF shall be designed to contain the volume, level, and characteristics of contaminated sediment to be placed within it, using site-specific designs as needed to accommodate the specific contaminated materials proposed for disposal. The design should consider representative sediment contaminant concentrations and contaminant mobility data obtained from, or estimated for, sediments from Portland Harbor sites where dredging is a reasonably anticipated remedial action.
- The CDF shall be designed to minimize water flow into and out of the CDF, including preventing or restricting preferential flow paths of clean or contaminated groundwater into or out of the CDF.
- The CDF shall achieve confinement of all hazardous substances disposed of in the facility through the groundwater pathway so that the CDF does not contribute any long-term discharge and/or release of contaminants above ARARs under federal or state law for surface water in the Lower Willamette River.
- The CDF shall limit contaminant concentrations in groundwater exiting the CDF to levels below USEPA's national recommended chronic water quality criteria for both aquatic organisms and fish consumption by humans (17.5 grams per day [g/day]), more stringent Oregon water quality standards, and maximum contaminant levels (MCLs) without dilution in the water column. The base case analysis shall not consider biodegradation. Groundwater exit concentrations are to be met in the berm, immediately prior to entering the surface water, not including riprap. It was subsequently clarified that groundwater exit concentrations would be spatially averaged over the area of the CDF berm face to evaluate fish consumption criteria.

- The CDF berm shall be designed to:
  - Provide a static safety factor of 1.5 or greater and a seismic safety factor of 1.1 or greater. The design seismic event shall correspond to a 10 percent probability of exceedance in 50 years.
  - Be resistant to erosive forces by the largest of 100-year flood flow, 100-year waves, and vessel-induced waves from typical passing vessels as well as vessels that operate in the area.
  - Have an appropriate gradation to allow transport of groundwater while retaining (filtering) sediment during filling and after closure.
- The CDF shall not measurably increase the 100-year flooding stage or decrease flood storage of the Willamette River.
- The CDF shall minimize releases of 303(d) listed contaminants to the extent practicable.
- The CDF berm and related components shall be constructed in a manner that complies with water quality ARARs during construction and filling of the CDF.

5.1.2 CDF Design Objectives and Related Criteria

The CDF design objectives were developed in consideration of the CDF performance standards listed above. The following design objectives and related criteria were used to design the CDF:

- **Develop a containment berm that is stable and will contain the confined sediment under a design-level seismic event and withstand erosion-generating forces.** The configuration of the berm was designed to be a stable structure based on a static factor of safety of greater than 1.5. In addition, the structure was designed to have a seismic factor of safety of 1.1 or greater and to withstand erosion from river currents associated with a 100-year flood, wind-induced waves typical of the T4 site, and propeller wash generated by the size of vessels that typically transit into and out of T4.
- **Select berm materials with permeabilities that allow transport of groundwater through the berm structure while retaining solids.** The berm is designed to be permeable and to allow the transport of groundwater through the structure, while

containing the contaminated sediments in the CDF behind the berm and prevent them from "piping" into the berm material.

- **Design the berm such that its permeability, composition, and configuration result in groundwater exit concentrations that are protective of the beneficial uses in the Willamette River.** Modeling of groundwater moving through the CDF berm with specified permeability, composition, and geometry was used to predict chemical concentrations that would be transported to the Willamette River. The modeling was performed to confirm that chronic water quality criteria, fish consumption criteria, and drinking water MCLs (as directed by USEPA) are met in the porewater of the CDF berm (not including riprap) without dilution in the water column over the design life of the facility.
- **Minimize water quality impacts to the extent practicable outside of the construction zone.** The need to meet water quality criteria for both conventional parameters (e.g., turbidity, DO, pH, and temperature) and contingent chemical parameters (e.g., TSS and target laboratory analytes) factored into the selection of berm material placement methods and the operation of the CDF during filling. In particular, the filling operations will be managed to achieve zero direct discharge of effluent from the facility (i.e., no weir discharge). Water quality monitoring activities, standards and criteria for construction of the berm are described in the WQMP (Appendix E).

5.1.3 Additional Considerations

Additional considerations that were essential to the design of the CDF include the following:

- Consolidation and settlement characteristics of the dredged material placed within the CDF.
- The contaminated sediments behind the berm must remain saturated to minimize leachability. Groundwater modeling was used to determine the elevation at which material will be saturated at all times. This elevation was determined to be 9.5 feet NGVD, which is the upper elevation at which contaminated sediments will be placed into the CDF.

- Future plans for the use of the upland terminal area created by completion of the CDF.
- The assumption that, in the future, the navigation channel outside of the berm may be dredged to a maximum depth of -46 feet NGVD.
- The CDF must not impact the Willamette River flood stage.
- Slip 1 structures must be demolished prior to material placement in the CDF.
- Stormwater outfalls that currently enter Slip 1 should be re-located prior to placement of material into the CDF.
- A replacement berth for those demolished in Slip 1 will be constructed parallel to the berm face.

5.2 CDF Berm, Fill, and Surface Layer Design

This section describes the design of three different CDF components—the containment berm, dredged fill layers, and the surface layer. Each component is described in detail below.

5.2.1 Containment Berm Constructability

Contractors commonly build underwater berms using training terraces (sometimes called training dikes). The terraces are constructed of quarry spalls or smaller sized riprap. They are constructed at the edges of the berm and are used to contain the select fill placed in between them. Because the select fill cannot be compacted, as is done with traditional berm or embankment construction above water, the training terraces are used to contain the select fill. If the training terraces were not used, the select fill could not be placed at the specified 2H:1V side slope. The side slopes would likely be closer to 3H:1V or 4H:1V, which would require more aquatic area and reduce disposal capacity. The approach of using training terraces was similarly used for the construction of the Milwaukee Waterway, Eagle Harbor (West Harbor Operable Unit), Port of Tacoma Slip 1, and St. Paul Waterway containment berms in USEPA Region 10.

The optimal size of the training terraces is a function of rock costs and ease of construction. For instance, larger training terraces allow the select fill to be placed more efficiently at a lower cost; however, because the training terraces are larger, they require more rock and are more costly. On the other hand, smaller training terraces use less rock and more select fill, so they have lower material costs. However, they require more time to construct, reducing productivity and increasing costs. Therefore, there is an optimal size that balances production and material costs. The CDF capacity for contaminated sediment and the potential for impacts to the Willamette River floodway are additional factors to be considered in the design of the training dikes and the berm.

There are two primary design elements that are impacted by the size of the training terraces: 1) seismic stability of the berm; and 2) contaminant transport through the berm. The Conceptual (30 Percent) Design evaluated the size of training terraces and found that the berm would contain the confined sediments during a design-level earthquake with training terraces ranging from 3 to 20 feet high. A review of the berm design by a regional contractor indicated that the use of larger training terraces would greatly improve constructability. During Conceptual Design, however, the berm design included a habitat bench near elevation 0 feet NGVD which increased the stability of the structure. Subsequently, at the request of USEPA and its partner agencies, the habitat bench was removed from the design. A geotechnical evaluation of the revised berm geometry indicates training terraces no smaller than 20 feet high should be used. In addition, the geotechnical evaluation indicates a toe buttress should be placed on the outward face of the berm from the base up to elevation 0 feet NGVD to achieve the required factors of safety (see Figure 5-2 and Appendix H). The toe buttress would be constructed of toe buttress material and Armor Material Type 5.

Contaminant transport modeling of the containment berm was performed using 20-foot-high training terraces (see Appendix A). Through the modeling analysis, it was determined that water quality criteria would be met in the porewater of the berm without dilution in the water column, as directed by USEPA (2010a), thereby protecting the beneficial uses of the Willamette River.

5.2.2 Containment Berm Stability

Appendix H presents a detailed summary of the CDF containment berm geotechnical design. Figure 5-2 shows a generalized cross section through the containment berm.

The conceptual berm configuration evaluated for stability was modeled after the containment berms used for the St. Paul and Port of Tacoma Slip 1 CDFs. The conceptual design of the berm incorporates 2H:1V inward and outward faces. Similar to the other Region 10 CDFs, the berm material will be constructed of sandy gravel or gravelly sand, and training terraces consisting of quarry spalls will be placed at both ends of the CDF to assist with construction. The training terraces will be 20 feet high, built with 2H:1V outer side slopes and 1.5H:1V inner side slopes.

In front of the berm, a toe buttress will be placed from elevation 0 feet NGVD to the toe of the berm. The width of the toe buttress will be 5 feet at elevation 0 feet NGVD tapering to 20 feet wide at the toe of the berm. The toe buttress will consist of toe buttress material and Armor Material Type 5 as shown on Figure 5-2.

Behind the berm, contaminated dredged sediments will be placed to elevation 9.5 feet NGVD or below so that they will remain in a saturated condition at all times. Fill material will be placed above the contaminated sediment. The upper portion of the CDF will be filled with imported granular materials (see Figure 5-2).

5.2.2.1 Methods of Stability Analysis

A number of typical cross sections through the berm were developed and analyzed for global stability, similar to the approach used to assess the stability of the St. Paul and Port of Tacoma Slip 1 CDFs in Puget Sound. Based on the preliminary analysis, the cross section through the middle of the berm was determined to be the critical section (i.e., possessing the lowest factors of safety).

Stability modeling was conducted with GeoSlope's software package SLOPE/W. The software employs a limit equilibrium methodology for calculating a factor of safety against sliding or sloughing. The analysis was completed using Spencer's method, which satisfies both moment and force equilibrium.

Soil parameters used in the analyses were developed based on the results of the geotechnical review. SPT blow counts, CPT values, laboratory strength testing, and gradation data were used in concert with published references to develop preliminary strengths and unit weights. Statistical distributions were applied to each value based on a subjective evaluation of the potential variability of assumed and measured data. The values assumed for non-native soils (dredged material) are comparable to assumed values used in designing the St. Paul and Port of Tacoma Slip 1 CDF facilities. A summary of soil parameters employed in the analyses is presented in Appendix H.

The berm section was evaluated for the following four cases:

- Short-term (during filling) static (Section 5.2.2.2)
- Long-term (post-filling) static (Section 5.2.2.3)
- Long-term (post-filling) seismic (Section 5.2.2.4)
- Long-term post-earthquake static (Section 5.2.2.5)

For each case, the slope stability factor based on the most critical circular slip planes was evaluated. The calculated slip planes that pass anywhere through the berm, as well as slip planes that pass through the contaminated dredged material, were also evaluated to determine which of these have the lowest factor of safety. These slip planes are referred to as the shallow slip plane and the deep slip plane, respectively. The deep slip plane represents a deep-seated stability failure that could potentially result in release of contaminated sediment. A graphical representation of the results of each of these analyses is shown in Appendix H.

5.2.2.2 *Short-Term Static Stability*

The critical section for the short-term static stability reflects the conditions present during filling of the CDF when the entire CDF may be used to decant hydraulically dredged sediments. The analysis was based on the most critical case for this condition, with the dredged sediment placed, the water in the CDF to within 2 feet of the crest of the containment berm, and the river at a low water stage. Since the CDF will not be filled hydraulically, this conservative condition is unlikely.

Based on these very conservative assumptions, the slope stability factor of safety relative to a shallow slope movement was 1.52. The factor of safety for slope stability for a deep slope movement that would intersect the decant water in the pond was 1.72. These values indicate that the berm would be stable during hydraulic filling. Note that the condition modeled is not anticipated to actually occur because mechanical dredging is the likely method of filling the CDF for most, if not all, of the AOPCs in Portland Harbor.

5.2.2.3 *Long-Term Static Stability*

The long-term static stability case reflects a finished condition for the CDF. For this case, it was assumed that the groundwater table within the CDF would approach current levels observed inland of Slip 1. The factor of safety for the long-term static stability analysis was 1.62. The factor of safety for deep slope movements was 2.00. These values indicate that the berm will be stable under normal operating conditions.

5.2.2.4 *Seismic Stability*

In accordance with the USEPA-approved EE/CA (BBL 2005) and the Action Memo (USEPA 2006a), the CDF and the containment berm were evaluated for stability against a contingency level seismic event. The contingency level event (CLE) represents an earthquake with a 10 percent probability of exceedance in 50 years (i.e., 475-year return period). During the CLE, waterfront facilities may suffer significant damage that would impair operations and major repair work would likely be required, but no catastrophic failure would develop. Although design components, such as a CDF containment berm, may suffer deflections, containment of the contaminated sediments would not be jeopardized.

The Action Memo (USEPA 2006a) requires the following design-level geotechnical seismic analysis for assessing the stability of the CDF containment berm:

- Detailed characterization of seismic sources (known regional faults) in the vicinity of the T4 CDF for development of a site-specific seismic hazard analysis.
- Development of input ground motions from seismic sources considering site-specific geotechnical considerations.
- Evaluation of liquefaction potential for CDF containment berm, foundations soils, dredge sediment, and surrounding site soils potentially contributing to instability of the CDF during the design-level earthquake, including evaluation of liquefaction-induced deformations and lateral spreading.
- Evaluation of slope stability and deformation for both pseudo-static and post-earthquake conditions.
- Development of a contingency plan for post-earthquake inspection and repair.

The seismicity of the Portland Metropolitan area, and hence the potential for ground shaking, is controlled by three separate fault mechanisms. These are the Cascadia Subduction Zone (CSZ), the mid-depth intraplate zone, and the relatively shallow crustal zone. Descriptions of these potential earthquake sources are presented in Appendix H. These sources were used to determine a design peak ground acceleration (PGA) to be used for seismic stability assessment.

A Probabilistic Seismic Hazard Evaluation (PSHA) using the most up-to-date information from agencies such as the USGS, Department of Geology and Mineral Industries (DOGAMI), and the Oregon Department of Transportation (ODOT) was completed to determine the appropriate seismic acceleration to use with stability design. This information has been supplemented with seismic hazard data from numerous other technical resources. On the basis of the PSHA analyses, the two primary seismic sources considered for design purposes have been considered to include: 1) a magnitude 9.0 mega-thrust earthquake along the CSZ having a source-to-site distance of roughly 96 kilometers (km); and 2) a magnitude 6.2 shallow, crustal event with a source-to-site distance of 12 km. The relative contributions of the two closest faults, the Portland Hills Fault and the East Bank Fault, to the cumulative seismic hazard are small for the return period of interest (475 years). In light of the low slip rates and corresponding low rates of seismicity estimated for these faults, and based on input from DOGAMI personnel who are actively studying these faults (Madin 2006), these two potential seismic sources have not been incorporated in the current analyses. The design team has selected the following scenarios for subsequent analysis of dynamic soil response, soil liquefaction, and design for the CDF berm:

- Magnitude 9.0 CSZ event resulting in bedrock ground motions of 0.14g beneath the T4 CDF.
- Magnitude 6.2 crustal source resulting in bedrock ground motions of 0.20g.
- The intraslab (or intraplate) source has been shown to contribute the least to bedrock peak acceleration and spectral accelerations (0.2 and 1.0 second), and was therefore omitted from further consideration in the analyses.

Appendix H presents the seismic hazard analysis. A dynamic soil response analysis was then performed to estimate the PGA at multiple locations in the berm for the different seismic events. Dynamic soil response analysis considers the amplification effects of site soils above the bedrock to estimate a PGA at the containment berm. The results of this analysis determined that a PGA of up to 0.33g for a 475-year return interval event was appropriate for the site (see Appendix H).

5.2.2.5 Pseudostatic Stability

The seismic case was developed based on the 475-year return interval event. In accordance with widely accepted analysis methods, a value equal to one-half of the peak horizontal acceleration developed from the seismic analysis was used to assess pseudostatic stability.

Results of the analysis show that the factor of safety relative to shallow, surface movement was 1.00. The factor of safety for deep shear surfaces that intersect the dredged sediments was 1.10. This analysis indicates that the potential exists for displacement of the berm toe under a design-level earthquake event. However, the remaining berm possesses sufficient residual strength to contain the contaminated sediments within the CDF.

The impact of a progressive failure of the toe of the berm resulting from a design earthquake was evaluated. In order to evaluate this potential, it was assumed that the deepest failure surface with a pseudostatic factor of safety of less than 1.1 occurred. Further, it was conservatively assumed that all of the material within the slide block was removed by river currents. For strength values, the reduced strengths described in Section 5.2.2.6 were used. These values include strength reductions for excess pore pressures and liquefaction. Ultimately, these phenomena would be short-lived. Even with these conservative assumptions, the results of this analysis indicate that the factor of safety against a further shallow failure is in excess of 1.3.

5.2.2.6 Post-Earthquake Stability

For the post-earthquake stability scenario, the strength parameters of the berm and foundation materials used in the static case were modified to account for strength loss from the seismic event.

The potential for soil liquefaction during seismic ground shaking is generally associated with loose to medium dense, saturated, non-plastic sands, and some very soft, recently deposited silt soils. The soils present in the area of Slip 1 consist of medium dense sands overlying very dense gravels and cobbles. The medium dense sands invariably have some liquefaction potential during near field earthquakes. Appendix H presents a summary of the conceptual liquefaction analysis completed to date. This analysis indicates that some of the foundation sediments below the CDF containment berm are susceptible to liquefaction. The post-earthquake stability analysis considers the liquefaction under the berm.

The factor of safety relative to shallow, surface movement on the berm face was greater than 1.04. The factor of safety for the deep shear surfaces that potentially intersect the dredged sediments was 1.35. These values indicate that the berm will be stable after a design-level earthquake.

5.2.2.7 Seismically-Induced Berm Deflection

The post-earthquake stability analyses provide the margin of safety against lateral ground deformation for conditions that exist immediately after the ground shaking has stopped. At this time, it is conservatively assumed that any excess pore pressures that may have been generated during the earthquake event still exist in the soil layers and possible degradation in soil strength is incorporated into the stability model. While this procedure provides a useful parameter (safety factor) for assessing the likelihood of permanent earthquake-induced deformations, it does not provide explicit estimates of the likely slope movement. As previously addressed, the CDF berm can undergo limited, tolerable deformations and continue to contain the contaminated soils in an acceptable manner. A deformation-based method of design, similar to that adopted for large earth dams, has been employed on this project.

As described in Appendix H, two methods were used to predict the amount of deflections (Dickenson et al. 2002; Jibson and Jibson 2003). Conservative input values were used for the modeling. The estimated total displacement ranged from 1 to 2 feet for large-scale, deep-seated movements. These small amounts of displacement will not compromise the integrity of the CDF.

5.2.2.8 Summary of Stability Results and Conclusions

Based upon the analysis, the CDF structure as proposed is protective of the contaminated sediment placed within the CDF. The structure will adequately protect and contain the dredged sediment. The berm design and corresponding safety factor reflect a number of modifications and improvements. The foundation of the berm will be overexcavated and backfilled with structural fill. For the majority of the berm structure, the removal of loose sediment will likely be less than 5 feet, but in some locations the removal thickness could be

10 feet. The current design assumes that 5 to 10 feet will be removed below the outer toe of the berm.

Static factors of safety in excess of 1.5 and seismic factors of safety in excess of 1.1 are broadly considered stable for earth structures in cases where nominal permanent deformations are acceptable. For all cases, the factors of safety against a deep slope movement were far in excess of these values. The berm as conceptually designed will prevent the physical release of contaminated sediment.

The analysis did indicate the potential for deformations of the berm face due to a design seismic event. The shallow slope movement is considered to be within tolerable ranges, although such deformations would require rebuilding the outer face of the berm—the analysis indicates that the contaminated sediment would not be impacted. The risks associated with shallow surface sloughing are comparable to the risks associated with most waterfront facilities in the Portland area.

For each case evaluated, the statistical evaluations indicate that the probability for a deep movement that would impact the dredged sediments was zero. This analysis indicates that the proposed design more than adequately addresses the potential for variability within the strength of the soils present and proposed for use in the construction of the berm.

5.2.3 Containment Berm Erosion Resistance

The outward face of the containment berm will be exposed to potential erosive forces including river currents, waves, and propeller wash. To resist this erosion, an armor layer will be placed on the face of the berm. This section presents the design approach and results for the armor sizing.

Appendix G presents the detailed analysis of propeller wash-, river current-, and wave-induced erosion potential on the berm face. Each of these conditions is summarized below:

- **River Current.** WEST Consultants, Inc. used the LWG's river-wide Environmental Fluid Dynamics Code model and refined the existing grid to provide increased resolution at the berm face. The predicted currents associated with the 100-year flood flow conditions along the face of the berm are presented in Appendix F. At the lower section of the berm (-35 to approximately -15 feet NGVD), the velocities range from 1.01 to 1.32 feet per second (fps) resulting in a medium sand needed for erosion protection. Along the upper section of the berm (elevation -15 to +25 feet NGVD), the velocities decrease to 0.42 to 1.14 fps, resulting in the need for a fine to medium sand. Therefore, at a minimum, a medium-sized sand is required to resist the river current velocities.
- **Waves.** For wind-induced waves, a medium sand is needed to resist the bottom shear stress due to the passing wave prior to breaking. As the water depth over the berm decreases to roughly 2.5 feet, a fine gravel is required. For vessel-induced waves, a coarse gravel is required to resist the orbital velocity of a passing wave. Breaking waves impart more erosive force on the berm than a passing wave. A riprap-sized material (median diameter [D_{50}] between 7 and 10 inches) will be necessary to protect the berm within the surf zone areas. The surf zone is assumed to be at elevation -3 feet NGVD, given a river level elevation of 0 feet NGVD up to ordinary high water (OHW), 16.6 feet NGVD. Therefore, at a minimum, a coarse gravel is required to resist the subsurface force of a wave approaching and a riprap-sized material is required to resist the force of a wave crashing in the surf zone.
- **Propeller Wash.** To assess the propeller wash potential imparted on the berm face, the new replacement berth and Berth 401 were assumed to be operational and supporting ship traffic. Both tugs and ocean-going vessels were evaluated at different river stages. The analysis indicates that riprap will be needed on the berm face; the gradation depends on the elevation. From elevation -25 feet NGVD to the toe of the berm, riprap with a D_{50} of 15 inches is required. From elevation -25 feet NGVD to -10 feet NGVD, riprap with a D_{50} of 7 inches is required. Above that elevation, riprap with a D_{50} of 4 inches is required. Therefore, at a minimum, a riprap is required to resist propeller wash from approaching vessels.

In summary, to properly design the face of the berm to resist the most critical erosional forces, the largest sized armor was selected. For the berm face, the armor layer is controlled by the propeller wash and crashing waves. In summary, the face of the containment berm adjacent to the river will require riprap with a D_{50} of 15 inches from elevation -25 feet NGVD to the berm toe, and D_{50} of 7 to 10 inches above -25 feet NGVD up to the OHW.

5.2.4 Containment Berm Consolidation

The weight of the berm will induce consolidation of the sediments beneath the berm, causing the berm to settle. Consolidation properties of the sediment below the berm were derived from the completed explorations. The settlement of the berm was estimated by applying the weight of the berm on the subgrade soils. Settlement properties of the subgrade soils were estimated from the CPT results completed in the berm footprint. The material under the berm is predominantly granular. The analysis predicts approximately 4 feet of settlement under the weight of the berm. The berm settlement will occur predominantly as the berm is constructed. That is, after the berm is constructed to grade, long-term settlement will be negligible.

5.2.5 Consolidation and Settlement of Contaminated Dredged Sediment

Similar to containment berm consolidation, the weight of the sediment placed within the CDF will also induce consolidation. This consolidation has been considered in order to determine the total amount of contaminated dredged sediment that can be placed into the CDF. The contaminant transport model of the CDF indicates that the top elevation of the confined contaminated sediment will be 9.5 feet NGVD. Not considering consolidation, the capacity of the CDF for contaminated dredged sediment up to 9.5 feet NGVD is approximately 670,000 cy. Contaminated dredged sediments will include material from T4 and other sites within the Portland Harbor Superfund Site. As this material consolidates to a denser condition than is found in situ and the foundation materials below the CDF consolidate, additional contaminated sediment will be able to be placed below elevation 9.5 feet NGVD. The remainder of this section details the expected consolidation and predicts the additional capacity for the dredged contaminated sediments that can be accommodated within the CDF below elevation 9.5 feet NGVD.

The contaminated dredged sediment will settle due to two factors: 1) consolidation of the dredged sediment placed within the CDF; and 2) consolidation of the sediments below the CDF. The two factors are described in detail below.

5.2.5.1 Consolidation of the Confined Contaminated Sediment

As the contaminated sediment is placed, consolidation and settlement will occur, induced by the weight of the sediment itself and from the weight of the import fill and cover layers placed above.

Dredged material initially placed within a CDF is typically at a higher moisture content than is found in situ prior to dredging. This is because the dredging activity breaks down the sediment structure, entraining more water into the sediment matrix. As more and more sediment is placed in the CDF, the previously placed dredged sediment consolidates due to the additional weight. With time, this consolidation process will reduce the water content of the contaminated sediment within the CDF to below what is found in situ prior to dredging.

Geotechnical information on dredged sediment and subsurface soil samples was used with computer models to estimate the total amount of the settlement. Procedures outlined in USACE's Confined Disposal of Dredged Material (USACE 1987) were used along with constitutive models that use laboratory-derived relations to predict the amount and duration of sediment settlement (Stark 1996; Znidarcic et al. 1992). The computer program CONDES (Yao and Znidarcic 1997) is a constitutive model that was used to estimate the total amount of settlement of the confined contaminated sediments. This program estimates both the amount of settlement and the time rate of settlement assuming certain fill rates and material properties.

Consolidation properties of the fill material were obtained from laboratory tests on representative samples of the dredged material from T4 Slip 3 (Anchor 2006c; Pre-

Construction Sampling Data Report). Two composite samples were analyzed from Slip 3 (Comp-1 and Comp-2). For the analysis described in this section, the consolidation properties of dredged sediment from other AOPCs in Portland Harbor were assumed to be similar to the properties of the dredged sediment from Slip 3.

The computer program CONDES was used to estimate the amount of sediment settlement. Figure 5-3 illustrates the top elevation of the contaminated sediment within the CDF during the filling process. The line represents the elevation of the top of the placed material. The initial steep upward portion of the curve represents the filling process during the available 4-month fish window (July through October). The flat or downward segment after the filling period is the settlement that occurs during the 8-month fish closure period (November through June). The filling period and subsequent waiting period create a "step" on the graph.

Each step represents a season of placement of contaminated sediments from various AOPCs in Portland Harbor. The filling process is estimated to take up to 4 years to complete, although it could take longer or shorter depending on the schedule of the Harbor-wide remedial action and the availability of suitable dredged material. After the contaminated sediment is placed, the imported fill and surface layer comprised of structural fill would then be placed. On the graph these are represented by the period between years 4 and 6. Again, this filling process could take longer or shorter than the assumed 2 years, depending on the availability of materials.

As can be seen on Figure 5-3, if 670,000 cy of in situ contaminated sediment were placed within the CDF, the top of this layer would be between elevation 0 to -9 feet NGVD after the imported fill and structural fill are placed. This indicates that an additional 9 to 18 feet of contaminated sediment could be placed within the CDF and still be below elevation 9.5 feet NGVD. Much of this capacity would be gained within a few years of placing the imported cover material over the contaminated dredged sediment. Because the contaminated dredged sediment will be covered with more than 18 feet of imported fill material plus an additional 4.5 feet of select fill material, the contaminated dredged sediment would be fully confined by the elevation of the berm and the surrounding peninsulas even if it were temporarily overfilled by 9 to 18 feet. Further details regarding the CDF fill design and capacity optimization will be provided in the T4 CDF 100 Percent Design.

5.2.5.2 Consolidation of Foundation Below the CDF

Consolidation properties of the foundation below the CDF were derived from the completed explorations. The material under the CDF is predominantly granular with some silts. The analysis predicts approximately 2 to 4 feet of settlement under the weight of the fill. Due to the relatively slow filling schedule for the CDF, the settlement is anticipated to occur during filling.

5.2.5.3 Total Estimated Settlement

The consolidation of the confined contaminated sediment within the CDF with the consolidation of the CDF foundation indicates that an additional 11 to 22 feet of contaminated sediment could be placed within the CDF. This equates to an additional 200,000 to 300,000 cy of capacity for the CDF.

The predicted amount of settlement will need to be monitored during filling to confirm the theoretical calculations presented above. As part of the 100 Percent Design, a settlement monitoring program will be developed to monitor the settlement. In addition, material proposed for confinement within the CDF will need to undergo consolidation testing so that the settlement model can be updated.

5.2.6 CDF Surface Layer

The last stage of the CDF construction is the placement of the CDF surface layer (see Figure 5-2). Approximately 146,000 cy of material will be placed as the surface layer. The surface of the CDF will have a layer suitable to support long-term site uses. This layer will be constructed of imported granular material. Figure 5-2 shows the thickness of the surface layer. This surface layer will be graded for drainage and site use.

As discussed in detail in Section 6.5, the surface of the CDF does not need an asphalt pavement in order to meet water quality criteria in groundwater exit concentrations—infiltration of surface water does not adversely impact the groundwater quality discharging at the berm face. The ultimate post-filling use of the CDF surface by the Port is currently not known. Therefore, given these two factors, the 60 Percent Design assumes a compacted crushed rock surface.

The surface layer will consist of 4 feet of compacted sandy gravel/gravelly sand. The material will be placed in 12-inch lifts and compacted to a required density. On top of the compacted select fill will be 6 inches of compacted crushed rock, with the upper 2 inches being a finer graded material. The crushed rock layers will also be compacted to a required density.

Figure 5-4 shows the conceptual grading plan for the CDF surface layer. The surface grading plan will be finalized as part of the 100 Percent Design. Once future development plans are identified, appropriate stormwater conveyance and treatment systems associated with the planned development will be implemented under a separate permit process unrelated to this action. The current surface of the CDF is being designed to be pervious and to minimize stormwater discharge to the Willamette River.

5.3 Fish Removal

In order to minimize take of listed fish species and to ensure compliance with ORS 509.585 regarding providing fish passage, an effort will be made to remove fish from Slip 1 prior to dredged material placement in the CDF. Fish removal will occur following initial berm construction just before and after the height of the berm isolates water in the CDF from the river, and prior to dredged sediment placement in the CDF. During the final design process, methods will be explored that could be implemented to encourage fish to leave the slip before the berm gets to a level that isolates the water in the CDF from the river. After the berm reaches a level that isolates the CDF from the river, an effort will be made to remove the remaining listed fish from the slip. Fish removal is expected to span 3 to 5 fishing days. This removal is intended to minimize impacts to listed fish, but will also have the effect of minimizing impacts to other fish species that are collected with the listed fish. Following this work, the absence (or near absence) of fish from the CDF pond should minimize or eliminate the potential contact of piscivorous birds with potentially affected water, sediments, or prey from Slip 1 during filling.

Based upon typical juvenile salmonid behavior, fish removal efforts will be focused on shallow water habitat and the top portion of the water column (NMFS 2005). Methods were selected that should be reasonably effective for the areas where juvenile salmonids and other fish are expected to be located, and are consistent with the provisions in the National Marine Fisheries Service (NMFS) fish collection guidance (NMFS 2000), typical methods used for fish collection (Murphy and Willis 1996), and with previous successful methods used to capture salmonids and other fish in the T4 vicinity (Gasco Removal Action, Anchor 2006d; and Portland Harbor RI/FS, Striplin et al. 2003). These methods are listed in order of expected catch effectiveness, and this order will be used in sequencing the effort, as follows:

1. Boat electrofishing at the head and sides of Slip 1 (including Berths 405 and 408)
2. Beach seines (if possible) in the open shore of the shallow water at the head of Slip 1
3. Research-size purse seines deployed by boat on the sides of Slip 1
4. Fyke nets extending from shallow to deeper water on the sides of Slip 1

During sampling, the fishing methods may be re-prioritized, or concurrent use of two or more methods may occur depending on field conditions, observed effectiveness, and catch rates, in order to maximize the potential for catching and removing as many fish as practicable.

Coordination will be ongoing with NMFS during this effort regarding actual catch per unit effort efficiencies achieved during the work. As stated previously, this removal would be expected to span approximately 3 to 5 days.

Once fish are captured, water quality conditions within fish transport systems (e.g., buckets or tanks) will be maintained as sufficient to promote fish recovery, including using brief holding times; aerators; and clean, cold, circulated water. Collected fish will be released into the river as quickly as possible in shallow water near the shore on the opposite side of the containment berm. The selection of release sites will be coordinated with NMFS prior to the fish removal effort. In the event of mortalities, federally listed fish will be transferred to the Services if requested.

All fish removal activity will be conducted in close coordination with NMFS to determine the removal effort duration and to evaluate the effectiveness of the activity. The entire collect-and-release operation will be conducted by the Port's consultant team of experienced fishery biologists to ensure the safe and appropriate capture and handling of fish. During the entire process, the substantive requirements of ODFW Scientific Taking Permits will be met. Collection and release information will be reported to USEPA and NMFS in a brief memorandum following the fish removal effort, including the means of fish removal, the number and species of fish removed, the condition of all fish released, and any incidence of observed injury or mortality.

5.4 CDF Filling Methods

Following construction of the containment berm, the CDF will be filled with dredged sediments. The filling of the CDF will occur by offloading barges with sediments dredged by clamshell. There is a potential that dredged material from Portland Harbor Superfund Site locations could be dredged hydraulically and pumped directly to the Slip 1 CDF. However, there are only a limited number of AOPCs for which hydraulic dredging would be feasible, most being too far removed and/or on the opposite bank of the river. If hydraulic dredging is performed, it will be managed such that there will be no direct discharge of effluent to the river.

Filling the CDF from the land side using mechanical equipment is another possible option. Such an option might be preferred if contaminated sediments from Portland Harbor were dredged and then taken to one or more centrally located dewatering and rehandling facilities, and from there hauled over land via rail or truck to their final repository. If such a scenario is selected for the Portland Harbor remedial action, further details regarding land-side filling of the CDF would be provided in the T4 CDF 100 Percent Design.

5.4.1 Mechanically Dredged Sediments

Mechanically dredged sediment brought from Portland Harbor Superfund Site locations will most likely be brought to the CDF via a haul barge—this material will need to be transferred into the CDF with a pumping system.

The contractor will be required to design the offloading system for material brought to the site by barge. It is anticipated that material will be transferred from the barge to the CDF using a dredge pump. The offload facility will be located at the new replacement berth. The Contractor will be required to design a system that includes the following requirements:

- Includes spillage containment systems and methods to monitor for any spillage
- Draws any make up water used to slurry the dredged material for pumping from within the CDF
- Has sufficient capacity to handle the anticipated supply rates
- Has the ability to place materials to all locations of the CDF

The offloading system would connect to a diffuser barge system similar to that described in Section 5.4.2. By using CDF pond water as the make-up water for the pump slurry, there will be very little change in the water level between the pond and the river and, as a result, minimal groundwater advection through the berm.

5.4.2 Hydraulically Dredged Sediments

For any potential hydraulic dredging, the sediment will be pumped hydraulically to a diffuser barge located within the CDF. The alignment of the dredge pipeline between the dredge and the CDF will either be in the water or over the upland. It should be noted that the current design assumes that hydraulic dredging will not be used to fill the T4 CDF. If circumstances change such that hydraulic dredging becomes a preferred filling option, additional analysis of weir overflow conditions, water quality effects, and other potential impacts, both short-term and long-term, would need to be assessed in either the 100 Percent Design or in the AOPC-specific design process.

The diffuser barge will reduce the energy of the dredge slurry, allowing the dredged sediment to settle out. The contractor will design the diffuser barge. The specifications will require that the diffuser barge meets the following requirements:

- Reduces the energy of the slurry material
- Is capable of delivering the slurry to any elevation within the water column
- Can be moved around the CDF to varying discharge locations

If filling progresses at a relatively fast rate, the water level within the CDF will rise. Most CDFs are designed with a weir structure, and if the water rises high enough, it is discharged over the weir and through a pipeline and outfall to river. If hydraulic dredging is used to fill the T4 CDF, the dredging rates, schedules, and resultant water levels in the CDF will be managed such that there will be no over-the-weir discharge of dredging effluent. If it becomes necessary to design a hydraulic dredging scenario with an effluent discharge to the river, the weir, pipeline, and outfall structure will be designed, and water quality modeling will be performed as part of the AOPC-specific design process.

Figure 5-5 shows the cumulative capacity of the CDF for different elevations within the CDF. Before filling, the water level within the CDF will likely be near elevation 0 feet NGVD. Up to elevations +15 to +25 feet NGVD, there is approximately 300,000 to 550,000 cy of storage capacity. As the CDF is filled, water will gradually seep through the surrounding ground and containment berm providing more storage capacity. However, if the berm becomes gradually plugged with fine-grained sediment, its seepage rate may decrease, thereby slowing the recovery of water elevations in the CDF pond and placing constraints on the hydraulic filling rate. It is expected that berm plugging should be minimized at T4 because of the well-controlled placement procedures, including use of CDF pond water as make-up water to slurry the dredged material over the berm, and use of a diffuser barge, which provides accurate placement control within the CDF, both spatially and vertically in the water column. If hydraulic dredging is selected as a preferred disposal method for one or more sites in the Harbor, a contingency option would be developed for decanting ponded water in case the berm plugs and the berm seepage rate cannot keep up with the dredge inflow rate.

5.5 Construction Quality Control During CDF Construction

A number of QC measures will be implemented by the contractor during construction of the different elements of the CDF. The CQAP (Appendix D) presents the details of these different elements. QC measures for each element are presented below:

- **Containment Berm Construction.** Construction performance standards and criteria associated with the construction of the containment berm include the following:
  - Achieve Specified Grades and Extents. Berm construction materials must be placed at the specified grades within 1 foot of the extents shown on the Drawings (Appendix B) and Construction Specifications (Appendix C). Surveys will be completed to confirm grades.
  - Achieve Proper Stability of the Containment Berm. Berm slopes must be constructed to the grades shown on the Drawings (Appendix B), and need to be monitored for stability throughout construction. Surveys and visual observations will be completed to confirm berm stability.
  - Verify Import Material Quality. Import material must meet specified physical properties, as outlined in the Construction Specifications (Appendix C), and chemical acceptance criteria, to be developed during T4 CDF 100 Percent Design, prior to the use of any imported material. Sampling and analysis of materials before and during construction, coupled with visual inspections of import materials, will be completed to verify suitability. Gravel (ASTM #10 sieve) will be excluded from chemical testing.
  - Minimize Short-term Water Quality Impacts. Water quality monitoring activities are required to ensure compliance with federal and state water quality standards. Water quality criteria for berm construction are described in detail in the WQMP (Appendix E).
  - Minimize Potential Impacts to Cultural Resources. Archeological monitoring activities are required in the Construction Specifications (Appendix C) to ensure no impacts to cultural resources or historic structures.

- **CDF Filling.** Construction performance standards and criteria associated with the filling of the CDF include the following:
  - Verify Fill Material Quality. Dredged material being evaluated for placement in the CDF will be subjected to physical, chemical, and leachate testing to determine whether the material is acceptable for placement, and to ensure that it will not cause adverse water quality effects. Bulk sediment and leachate test results for 12 AOPCs in the Portland Harbor are presented in the Groundwater Model Input Parameter Memorandum, Attachment 1 (Appendix A). Groundwater contaminant transport modeling results indicate that 10 of the 12 AOPCs would be suitable for placement in the T4 CDF without causing adverse water quality effects, as presented in the Long-Term Groundwater Modeling Results Memorandum (Appendix A).
  - Prevent Release of Dredged Material (Mechanical Transport). Action must be taken to minimize the potential for, and prevent releases of, dredged material during the filling of the CDF. Releases outside the CDF could also occur during transport. The specifications will require certain types of haul barges and BMPs for transport.
  - Minimize Spillage of Material at the Transfer/Offload Facility. Action must be taken to minimize the potential for releases of dredged material during the transfer or offloading into the CDF. The Construction Specifications (Appendix C) require certain measures be implemented to minimize spillage during offloading. In addition, sampling of the sediments at the offloading facility will be completed after offloading to confirm no spillage occurred. If spillage is indicated, remedial measures will be implemented to clean up the area.
  - Achieve Specified Placement Elevations. Materials must be placed to the specified grades within the specified extents as shown on the Drawings (Appendix B) and as determined by the acceptance criteria and approval process described in the Confined Disposal Facility Sediment Management Plan (Appendix J). Surveying requirements are defined in the Construction Specifications (Appendix C) for vertical and lateral confirmation during placement.

- <u>Achieve Expected CDF Consolidation.</u> Confirmation that settlement and consolidation of placed material are occurring as predicted in the design is necessary. The contractor will be required to install settlement plates within the cover material to monitor settlement of the dredged fill as a result of cover placement and self-weight consolidation.
- <u>Minimize Short-term Water Quality Impacts.</u> Water quality monitoring activities are required to ensure compliance with federal and state water quality standards during filling of the CDF. Water quality criteria for CDF filling activities are described in the WQMP (Appendix E).

- **CDF Covering.** Construction performance standards and criteria associated with the covering of the CDF include the following:
  - <u>Verify Import Material Quality.</u> Import material must meet specified physical and chemical properties prior to use. Physical and chemical acceptance criteria for the import fill layer, which will likely include suitable dredged material, will be developed during T4 CDF 100 Percent Design. Sampling and analysis of materials before and during construction, coupled with visual inspections of import materials, will be completed to verify suitability. Gravel (ASTM #10 sieve) will be excluded from chemical testing.
  - <u>Achieve Specified Cover, Thickness, and Extent.</u> Topographic surveys by the contractor will be required to confirm accurate placement of materials. The contractor will also be required to have a location control system appropriate to meet the construction tolerances.

5.6 Assessment of CDF Impacts on Willamette River Flood Stage

An assessment of potential impacts to the Willamette River as part of the EE/CA (BBL 2005) demonstrated that no rise in the base flood elevations would result from the CDF, and the action would comply with Federal Emergency Management Agency (FEMA) regulations. Compliance with the FEMA "no rise" criteria, completed and approved as part of Appendix K of the EE/CA (BBL 2005), has been confirmed with the existing CDF configuration as part of the 60 Percent Design using the same models and process (see Appendix I).

5.7 Demolition of Slip 1 Structures

A number of structures within Slip 1 will need to be demolished prior to filling. Removing the structures will allow more uniform filling of the slip. In addition, removal of the structures will eliminate subsurface obstructions that could potentially impact future foundation constructions. The structures and piling will be removed with a combination of land- and water-based equipment. Because of this, most demolition work needs to occur prior to topping of the containment berm across the mouth of the CDF.

Slip 1 currently contains two piers, one on each side of the slip. Berth 405 is located on the north side, while Berth 408 is located on the south side of the slip. These piers are wooden and concrete structures with asphalt or concrete topping that support storage and crane loads above. A system of wood piling and some steel piling is used as the fendering system at each pier.

The two existing open pier structures located in Slip 1, Berth 405 and Berth 408, will be demolished and removed as part of this project. The piles at Berth 405 are to be cut or broken off at the mudline. The piles at Berth 408 are to be pulled and removed to the extent practicable. Figure 5-6 shows the extent of demolition in Slip 1 required for the CDF construction.

Construction QC procedures to confirm that demolition meets the intent of the design are presented in the CQAP (Appendix D). Briefly, construction performance objectives for pile/structure demolition include the following:

- **Remove Specified Structures and Piles and Protect Remaining Structures.** It is necessary to confirm that the piles and structures identified in the Drawings (Appendix B) and Construction Specifications (Appendix C) have been adequately removed, and that structures not requiring removal are not damaged during the demolition operation. Performance criteria include total removal of specified structures and piles, and less than 1 inch of movement of protected structures (i.e., structures not identified for removal). Settlement monitoring of adjacent structures will be required of the contractor.

- **Appropriate Disposal/Recycling of Demolition Materials.** Demolition material removed from the Slip 1 area must be properly disposed of or recycled. The performance criterion is disposal or recycling of demolition materials at the appropriate facility as detailed in the Construction Specifications (Appendix C). The contractor will be required to track and document all loads of material leaving the site for disposal or recycling.
- **Achieve No Off-site Tracking of Contaminants During Transport of Disposal Materials.** It is necessary to confirm that there is no spreading of contamination during transit to the off-site disposal facility. The performance criterion is no statistical difference in the quality of soil/sediment samples collected before and after transit activities. The specifications will present requirements to minimize off-site tracking of contaminants. In addition, sampling will be completed to confirm no off-site tracking. An important component of the investigation will be to adequately sample pre-transport conditions to be able to distinguish whether or not the presence of contaminated soil/sediment in the post-transport condition can be reliably attributed to CDF construction activities.
- **Minimize Short-term Water Quality Impacts.** Water quality monitoring activities are required to ensure compliance with federal and state water quality criteria. Performance criteria are specified in the WQMP (Appendix E).
- **Minimize Potential Impacts to Cultural Resources and Historical Structures.** Archeological monitoring activities are required to ensure that construction activities do not impact cultural resources and historical structures.

5.8 Outfall and Stormwater Rerouting

The goal of the stormwater reroute is to relocate multiple existing discharge outfalls currently used by the Port and the City out of Slip 1. The reroute minimizes the number of trunk lines, as well as impacts to existing utilities and site surface features. Design and layout of the stormwater reroute system was based on estimated flow rates of adjacent basin areas, current outfall and utility locations, and location of new construction at Berth 401 and Pier 2 rail yard. Consideration was also given to minimizing the depth of excavation for installation and providing the shortest run possible.

Currently, five storm drain mains are known to outfall into the most inward (eastern) portion of Slip 1 at T4. Four of these are Port-owned and operated storm lines, while the fifth outfall is owned by the City. When Slip 1 is filled, these discharge points will be buried; therefore, these pipes will be relocated to provide suitable points of discharge into the Willamette River. Figure 5-7 shows the location of the new lines and outfalls. Three new lines will be run:

- Storm main A is the City's line. The line will run north of Slip 1.
- Storm main B is a Port line also running north of Slip 1.
- Storm main C is a Port line running to the south of Slip 1.

Computations indicate that a 36-inch-diameter main is required for all three relocated trunk lines. The Port-owned 36-inch-diameter main will pick up the four existing outfalls in a collection pipe. Due to the long runs to the Willamette River, a slope of 0.4 percent is used in the design for storm main A; 0.6 percent for storm main B; and 0.35 percent for storm main C. Pipe sizing was calculated using Manning's equation. With the assumptions of a minimum flow velocity (V) of 3 fps, Manning's coefficient (n) of 0.013, and a hydraulic radius (R) of 0.75 feet, a slope (s) of 0.001 feet/feet was calculated. At this slope, a 36-inch-diameter pipe will meet the assumed minimum velocity of 3 fps. Also, the flow capacity of this size pipe exceeds the flow rate maximums of the adjacent basin areas, calculated by the Rational Method. Storm drain manholes will be provided at all changes in direction and at a maximum spacing of 400 feet.

Because the contaminated dredged material in the CDF will be placed below elevation 9.5 feet NGVD, below the perennial water table elevation, and beneath more than 18 feet of imported fill plus 4.5 feet of select fill, it is unlikely that the storm drain utilities described above will be placed at or below the contaminated sediment elevation. Utility locations and elevations will be evaluated further during 100 Percent Design and, if necessary, design modifications may be made to prevent preferential flow of groundwater into or out of the CDF along the storm drain utility corridors.

5.9 Waterfront Structure(s) and Berth(s) Replacement

The new berth replacement pier is intended to provide a new berth for grain-carrying river barges, and act as a platform to support a grain offloading facility to be used by the Port's tenants. The dock is also intended to provide flexibility for future tenant use and is designed to support vessels up to the size of ocean-going barges. The dock has been designed to carry loads up to 1,000 pounds per square foot (psf) uniform load to support future uses of the dock structure, and will have vehicle access that is also designed for 1,000 psf to more easily accommodate future expansion. Additionally, this berth will be used to offload barges of mechanically dredged sediments from T4 and other Portland Harbor Superfund Site cleanup projects to fill the CDF. Figure 5-8 shows the location of the replacement berth.

The dock platform will be a precast, prestressed concrete platform supported by steel pipe piling. The concrete platform will provide an adequate base for the relocated grain unloading tower, and also provide maximum flexibility for the future use of the platform. Steel pipe piles were chosen due to geotechnical considerations in the berthing area and their ease of installation. The piles will be driven to sufficient depth to support the design loads.

The platform will be connected to the shore by a precast, prestressed concrete one-lane vehicle access trestle structure supported by steel pipe piles that are capable of supporting an American Association of State Highway and Transportation Officials (AASHTO)-rated H25 truck, large fork-lifts, container-handling top-picks, and a 1,000-psf uniform load. In addition, four ship berthing dolphins will be installed with catwalk access from the main platform. These dolphins will be spaced to accommodate ocean-going barges, as well as local river barges.

The structures associated with this new barge berth will require in-water work involving pile-driving operations, overwater concrete placement for the precast concrete pile bents, and installation of steel or aluminum walkways. It is anticipated that precast concrete deck panels will be placed by a crane-loaded barge, as will prefabricated steel or aluminum access catwalks.

5.10 Management of CDF Filling Activities

The CDF will be filled with contaminated sediment dredged from various AOPCs in Portland Harbor, as well as sediment from the Phase II Removal Action at T4. A layer of cover material will then be placed over the contaminated sediments. This section describes the criteria to be used to evaluate the suitability of dredged material for placement in the CDF, and how the CDF will be managed during filling events and between filling seasons (see also the Confined Disposal Facility Sediment Management Plan [Appendix J]).

5.10.1 CDF Acceptance Criteria

Dredged sediments proposed for placement in the CDF will need to meet certain physical and chemical acceptance criteria, as per the Action Memo (USEPA 2006a). These criteria include the following:

- **No Hazardous Waste.** Sediments designated as hazardous waste, whether listed waste or characteristic waste, are not eligible for placement in the CDF without adequate treatment.
- **No Free Oil.** Sediments containing "free oil" are not eligible for placement in the CDF without adequate treatment.
- **Suitable Geotechnical Properties.** The geotechnical properties of the fill materials must be of an acceptable quality such that they do not impact the long-term performance of the CDF, e.g., they must be free of debris and significant organics (i.e., wood chips), which could cause unacceptable obstructions, settlement, or gas generation.
- **Suitable Geochemical Properties.** The geochemical properties of the contaminated dredged sediments, primarily their leaching characteristics, must be shown to provide long-term protection of human health and the environment, and the beneficial uses of the Willamette River.

- **Other Considerations.** The Port and USEPA may consider other factors in determining acceptability of contaminated dredged material for placement in the CDF, including presence of principal threat compounds, physical nature of the material, form of the chemical contaminants, quantity of the material, long-term site liability, indemnification, and cost.

5.10.2 Portland Harbor Leaching Tests

The LWG conducted a series of leaching tests on contaminated sediments from 12 AOPCs in Portland Harbor, including most of the AOPCs considered a high priority for remedial action. Sequential batch leaching tests (SBLTs) were conducted, and the results of the leaching tests were input to the T4 CDF groundwater model to characterize long-term groundwater exit concentrations to the Willamette River. An evaluation of SBLT bulk sediment and leachate concentrations for Portland Harbor AOPCs is presented in Section 6.2.3 and Table 6-4, and in Appendix A, Attachment 1 of the Groundwater Model Input Parameter Memorandum. Model predictions of groundwater exit concentrations for five index chemicals are presented in Section 6.4.2 and Appendix A.

Groundwater model predictions indicate that ten of the 12 AOPCs evaluated would be suitable for placement in the CDF on the basis of their leaching characteristics. During the latter stages of design and during construction, when more is known about which AOPCs are being placed in the CDF and their respective volumes and sequencing, more detailed placement scenarios may be evaluated using the T4 CDF groundwater model to verify that water quality goals will be met.

5.10.3 Dredged Material Suitability Determination

An applicant representing an AOPC in Portland Harbor will need to submit data on its dredged material characteristics to be considered for placement in the T4 CDF. The data will be submitted for review and approval by the Port and USEPA and, if appropriate, a suitability determination will be issued for the proposed dredged material. The testing requirements needed to support a suitability determination will include the following:

- **Bulk Sediment Chemistry.** Bulk sediments will be analyzed for metals, semivolatile organic compounds (SVOCs), PCBs, chlorinated pesticides, and total petroleum hydrocarbons (TPH).
- **Bulk Physical Properties.** Bulk sediments will be analyzed for total organic carbon (TOC), grain size, and Atterberg limits. Consolidation tests may also be required for some sites.
- **Toxic Characteristic Leaching Procedure (TCLP).** TCLP testing for hazardous waste designation will be conducted for TCLP metals. Other TCLP parameters (TCLP volatile organic compounds [VOCs], SVOCs, and/or pesticides) will be determined on a case-by-case basis.
- **SBLT or Pancake Column Leaching Test (PCLT).** Sediment leachate testing (SBLT or PCLT) will be conducted for metals, SVOCs, PCBs, chlorinated pesticides, and possibly other parameters as determined on a case-by-case basis.
- **Other Testing Requirements.** If material will be placed in the CDF is such a manner that a weir overflow is expected, causing an effluent discharge to the Willamette River, a Modified Elutriate Test (MET) and Column Settling Test (CST) may be required.

Existing data collected as part of the Portland Harbor RI/FS may satisfy some or all of these data requirements. To the extent that additional field sampling and laboratory analysis may be required, a Sampling and Analysis Plan (SAP) must first be submitted to the Port and USEPA for review and approval prior to conducting the work.

5.10.4 Management of Filling Events

The requirements for management of CDF filling events are described in the Confined Disposal Facility Sediment Management Plan (Appendix J). The following management activities are described in the plan:

- **Port and USEPA Administration.** Responsibilities for administration of CDF filling activities, agency contact information, application requirements, and scheduling constraints for filling operations.

- **Management of Offloading.** Description of docking facilities, acceptable offloading methods, spill prevention requirements, and equipment necessary to properly place the material within the CDF to the elevations and extents identified on the Drawings (Appendix B).
- **Water Quality Monitoring.** Water quality monitoring requirements during filling events.
- **Environmental Controls.** Environmental controls for surface water management, dust control, and erosion control.

The performance of the CDF may be improved if sediment with relatively higher COC concentrations is placed near the upper head of the CDF (i.e., farther from the berm and underlying aquifer). Sediment with lower COC concentrations would be placed in the outer portion of the CDF, in particular, on the inside wall of the berm and along the bottom of the CDF. These areas have the shortest travel times to the river, which are measured in decades, whereas travel times in the upper head of the CDF may be 200 years or more (see Appendix A). It is expected that segregation of sediment will complicate construction sequencing by requiring tighter scheduling and coordination of disposal actions from various AOPCs in Portland Harbor, and as a result, increasing the cost and the time required to fill the CDF. The cost and schedule implications of dredged material segregation will not be fully understood until further progress is made with AOPC-specific remedial designs.

5.10.5 Management Between Filling Seasons

The following CDF inspection and QC measures will be implemented between filling seasons, as described in the Confined Disposal Facility Sediment Management Plan (Appendix J):

- **Physical Inspections of the Berm.** The containment berm will be inspected at the end of each filling season until the CDF is completed.
- **Physical Inspections of the Placed Material.** Bathymetric surveys will be completed at defined intervals to track the elevations of placed materials.

- **Interim Wildlife Protection.** Interim wildlife protection measures will be implemented during the latter stages of filling when the water depth above the contaminated sediments is shallow enough to pose a potential risk to wildlife, primarily piscivorous birds. When the water depth in the CDF is sufficiently shallow, a thin layer of clean sand will be placed over the contaminated sediment between filling seasons. During the initial part of the filling operation, such measures will not be necessary due to the significant water depths over the sediment and the initial removal of fish from the CDF following berm closure. Further details on placement of interim covers will be provided in the 100 Percent Design submittal.

It should be noted that the use of thin (approximately 6-inch-thick) sand layers for interim wildlife protection between filling seasons is not expected to create preferential groundwater flow pathways through the CDF. This expectation is based on the limited thickness of the sand layers, the likelihood that they will be mixed with underlying and overlying fine-grained sediment during placement, and that layers may be deformed and separated into discontinuous lenses during consolidation. The potential for preferential transport along such thin sand layers will be evaluated further during 100 Percent Design when the filling sequence is better defined.

5.10.6 Long-Term (Post-Construction) Management

Long-term management activities will be addressed in the Long-term Monitoring and Reporting Plan (LTMRP) that will be included as part of the 100 Percent Design. An outline of the LTMRP is presented in Appendix K. Long-term monitoring activities will include:

- **Visual Monitoring**
  - Armor Layer Stability, which will be assessed though a visual survey of the portion of the CDF armor layer that is above the water line. Transects will be walked at low water levels to complete the visual surveys.

- **Physical Monitoring**
  - Armor Layer Stability, which will be assessed through a bathymetric survey of the portion of the CDF armor layer that is below the water line.
  - Consolidation and Settlement Monitoring, which will be assessed though a survey of eight monuments located on the CDF berm and CDF surface.
  - Groundwater Level Monitoring within the CDF, which will be assessed through water level measurements at five monitoring well locations within the extent of the contaminant fill area of the CDF.
- **Chemical Monitoring**
  - Groundwater Quality Monitoring in the CDF Berm, which will be assessed through collection of groundwater samples at three downgradient monitoring wells in the CDF berm, one upgradient location, and two lateral locations (six monitoring wells total). Long-term groundwater quality parameters and criteria are provided in Table 6-1.

Long-term monitoring activities will be performed at the completion of construction (Year 0), as well as during eight post-construction events (Years 2, 5, 7, 10, 15, 20, 25, and 30).

5.11 Contingency Planning Measures

Contingency planning measures in the form of management and engineering controls could be implemented to enhance the performance of the CDF (if warranted) during CDF construction or in the future as a facility retrofit. Possible management and engineering control measures for the CDF are discussed in this section, including a brief review of their effectiveness, cost, and implementability. The effectiveness of the contingency options at reducing contaminant loads from the CDF is based on long-term groundwater model predictions (see Section 6.4 for a description of the T4 CDF long-term groundwater model). Unless otherwise stated, the addition of the contingency measures described below could likely be implemented within the +50/-30 percent level of accuracy of a feasibility-level cost estimate for the CDF.

The contingency options that were evaluated include the following:

- Restrictions on sediment acceptance
- Amending berm select fill
- Reducing the size of training dikes
- Amending dredged sediment during placement
- Paving the CDF surface
- Installing a permeable reactive wall in the berm

5.11.1 Restrictions on Sediment Acceptance

One possible control measure to reduce contaminant loadings from the CDF is to place restrictions on the acceptance criteria for sediment and leachate quality in the incoming dredged material. For example, it may be possible to reduce PCB leachate concentrations in the CDF by 83 percent by excluding the three most contaminated AOPCs. Based on the Portland Harbor leachate data, as compiled in Appendix A (Attachment 1of the Groundwater Model Input Parameter Memorandum, Table 1-1), the arithmetic mean Total PCB leachate concentration for the ten candidate AOPCs is 0.87 µg/L; however, if the Schnitzer, Gunderson, and Fireboat Cove AOPCs were excluded, then the arithmetic mean leachate concentration for the remaining seven AOPCs would be reduced to 0.15 µg/L (see also Section 6.2.3).

The opportunity cost of excluding certain AOPCs in Portland Harbor from placing their dredged material in the T4 CDF cannot be estimated with certainty, but it would nevertheless have an impact on the CDF being a cost-effective option. If there are fewer potential users of the CDF, then there is less revenue and the total cost of the CDF will increase. However, the magnitude of the cost increase is unknown at this time.

5.11.2 Engineering Control Measures –Construction

5.11.2.1 Amending Berm Select Fill

The select fill used to construct the CDF berm could be amended with an adsorptive material that helps to sequester COCs in groundwater. The performance of the CDF would be improved because the berm would have greater adsorbtive capacity and provide greater attenuation of COCs during groundwater transport. The adsorptive material used to amend the berm select fill would be based on the groundwater COCs that are targeted for reduction. For example, granular activated carbon (GAC) would be effective at sequestering most hydrophobic organic compounds (e.g., PCBs, DDx, and PAHs) (Barth and Reible 2008). Bauxite, apatite, and zeolites may have the ability to sequester certain inorganic compounds (Reible et al. 2006; Gavaskar et al. 2005; Jacobs and Forstner 1999).

One concept is to amend the berm select fill with GAC prior to placement between the training dikes. Due to the large volume of material that would need to be re-handled and processed, however, amendment of select fill material prior to placement would incur unnecessary costs and logistical complexity during berm construction. The preferred option for amending the berm is to install a permeable reactive wall in the berm after the CDF is constructed. The reactive berm wall is described in Section 5.11.3.2.

5.11.2.2 Reducing the Size of Training Dikes

Because of their enhanced permeability compared to the select fill, training dikes can create preferential flow pathways through the berm. Groundwater transport could be retarded, and the performance of the CDF could be enhanced if the size of the training dikes were reduced. The training dikes in the groundwater model were assumed to be 20 feet high. With the removal of the habitat bench from the face of the berm, the minimum height of the training dikes needed to provide long-term seismic stability is 20 feet. If the berm was keyed more deeply into the existing sediments, by over-excavating approximately 25 to 30 feet (the current design anticipates over-excavation of 5 to 10 feet), it may be possible to use smaller dikes on the upper tiers of the berm. However, such a design would involve over-excavation of a large amount of sediment (estimated at approximately 100,000 cy), as well as additional material costs for dike material and select fill to backfill the key excavation. The excavated material would require placement in the CDF, lowering the capacity of the CDF and increasing the per-cubic-yard disposal rate. For example, if the CDF capacity was reduced by 100,000 cy as a result of over-excavation needed to support smaller training dikes, the per-cubic-yard disposal cost would increase by 18 percent. As a result, this option is more difficult to implement and will incur significant additional cost, potentially exceeding the +50 percent level of accuracy required for the FS. Therefore, it is not considered further.

5.11.2.3 Amending Dredged Sediment during Placement

Dredged sediment placed within the CDF could be amended with an adsorptive material during placement. The performance of the CDF as currently designed would be improved as a result of the increased binding and decreased leachability of COCs within the amended sediment. The adsorptive material used to amend the dredged sediment would be selected based on the COCs that are targeted for reduction, for example GAC to control hydrophobic organic compounds (see Section 5.11.2.1). Adsorptive material could be added prior to or during pumping of mechanically dredged sediment from barges with high-solids pumps. Alternatively, adsorptive material could be introduced in-line with sediment that is being hydraulically pumped into the CDF. Due to the large volume of material that would need to be processed, and the variability in physical and chemical properties of the incoming material, amendment of dredged sediment prior to placement will incur additional costs and logistical complexity during CDF construction. In terms of implementability, this option is more difficult.

For costing purposes, it is assumed that the dredged sediment will be amended with 0.1 percent GAC. The estimated concept-level cost to amend the incoming dredged sediment with 0.1 percent GAC is approximately $16 million.

5.11.3 Engineering Control Measures – Post-Construction

The engineering measures described in this section carry a distinct advantage in that they could be implemented after CDF construction as a facility retrofit, for example, if post-construction monitoring results indicate unanticipated water quality issues are developing. With post-construction measures, CDF performance data can be reviewed and evaluated to better design an appropriate engineering solution.

5.11.3.1 Paving the CDF Surface

The addition of a paved surface on top of the CDF is expected to improve CDF performance by reducing the infiltration of incident rainfall, and likely causing a slight reduction in the groundwater gradient and flow velocity through the dredged sediments. The CDF groundwater model predictions are currently based on an unpaved (i.e., pervious) surface, in accordance with the current design consisting of 4 feet of select fill topped with 6 inches of crushed rock. The CDF cost will increase with the inclusion of a paved surface. However, the paved surface may be beneficial with respect to future use of the terminal. A particular implementability concern is that the paved surface will generate greater volumes of stormwater runoff that would need to be managed in terms of quantity and quality. Special challenges would be associated with stormwater management on the surface of the CDF due to the need to avoid siting engineered infiltration facilities over the contaminated dredged material, and to avoid creating preferential flow paths or accelerating groundwater transport through the CDF.

Without consideration of the cost of stormwater management, the cost to pave the surface of the CDF with a pavement section typical for truck traffic is approximately $2.4 to 4.0 million. Costs for pavement sections necessary to support heavier traffic (such as mobile container cranes) could be up to 10 times as expensive. The Port currently does not know the long-term use of the area.

5.11.3.2 Installation of a Permeable Reactive Wall in the Berm

The addition of a permeable reactive wall in the berm would improve CDF performance by sequestering COCs in groundwater, similar to amending the berm with adsorptive material (see Section 5.11.2.1). The berm would have greater adsorbtive capacity and provide greater attenuation of COCs during groundwater transport. It is expected that the amount of contaminant attenuation will be proportional to the amount of GAC (or other adsorptive material) that is added to the permeable reactive wall. A wall could be added as a retrofit to the existing berm at any point in time after berm construction. The wall would likely be constructed by excavating a trench along the top centerline of the berm alignment and introducing an amended slurry. The slurry would prevent the sidewalls from collapsing. Beyond the base cost of CDF construction, the additional cost of the wall will depend on the type (e.g., GAC, coke, etc.) and weight percent of adsorptive material that is added. Permeable reactive walls are implementable, having been successfully installed at numerous contaminated groundwater sites throughout the country, and at depths equal to or greater than the height of the CDF berm (USEPA 2002).

For costing purposes, it is assumed that the permeable reactive wall is 3 feet thick. Vertically, it spans the entire saturated zone of the berm, extending from above the water table to a footing in the underlying aquifer. The total wall length is approximately 1,050 linear feet, spanning the entire width of the berm and including several hundred feet of wing wall along the southern boundary of Slip 1 to protect Wheeler Bay from lateral migration from the CDF. Two scenarios are considered in which the reactive wall is amended with 0.1 percent and 1 percent GAC. The estimated concept-level cost to build a reactive wall in the berm with 0.1 percent and 1 percent GAC is $1.8 million and $2.0 million, respectively.

5.11.4 Cost-Effectiveness Comparison of Contingency Options

In this section, the cost-effectiveness of the different CDF contingency options is evaluated and compared. Estimated concept-level costs and underlying assumptions were described in the previous sections. The effectiveness of the different contingency options at reducing contaminant loads to the river was evaluated using the CDF long-term groundwater model. One metric that can be used to assess the effectiveness of the various contingency options is the duration of time over which the porewater at the berm face remains below the fish consumption criterion in the absence of biodegradation. This is referred to as the "travel time to the berm face." As discussed in Section 6.4.2, the fish consumption criterion is not likely to be exceeded with even a very small amount of biodegradation.

The estimated cost and environmental effectiveness (as measured in travel time to the berm face) of the various contingency options are summarized below:

Contingency Scenario	Control Type	Travel Time to Berm Face (years)	Conceptual Cost (millions)
Sediment Acceptance Restrictions	Management	700	Unknown
Paved Terminal Surface	Engineering	480	\$2.4 to \$4.0
Amended Dredge Fill, 0.1% GAC	Engineering	1,600	\$16
Permeable Reactive Wall, 0.1% GAC	Engineering	1,900	\$1.8
Permeable Reactive Wall, 1% GAC	Engineering	>>2,000	\$2.0

Note:
GAC = granular activated carbon

The reactive berm wall appears to be the most cost-effective contingency option for reducing the contaminant load from the CDF, if further reduction is determined to be necessary. Also, an advantage of this option is that it can be implemented retroactively after the CDF has been built, and in consideration of post-construction groundwater monitoring data, thereby avoiding potentially unnecessary over-engineering during CDF construction.

6 WATER QUALITY

This section presents the water quality standards and guidelines that will be used to construct the T4 CDF, results of contaminant mobility testing, and predicted water quality conditions during construction (short-term effects) and after construction (long-term effects). These factors will be used to inform the basis of design for the CDF, contractor-required BMPs to protect water quality during construction, and to develop short-term and long-term water quality monitoring programs for the CDF.

6.1 Water Quality Criteria

Short-term and long-term water quality effects associated with the T4 CDF are evaluated in this section. Short-term effects are temporary and transient effects associated with construction activities over periods of days and weeks, including dredging of the berm key and demolition of the pier structures in Slip 1. Long-term effects are associated with continuous movement of groundwater through the CDF berm over periods of years and decades. Water quality criteria used to regulate these various activities will be consistent with the scale and duration of exposure.

Proposed water quality criteria for the T4 CDF are summarized in Table 6-1.

6.1.1 Short-Term Water Quality Standards and Criteria

Short-term water quality criteria will be used to regulate in-water construction activities when the CDF is open to the river (e.g., during berm key dredging, demolition, and berm construction). The water quality criteria to be complied with during CDF construction are listed in Table 6-1. Water quality criteria will be met at the points of compliance described in Section 6.1.2.

Water quality monitoring requirements during CDF construction activities will be specified in the WQMCCP, to be issued by USEPA for construction of the CDF, to regulate placement of T4 material in the CDF, and final placement of imported fill material to close the CDF. The WQMCCP is the substantive equivalent of a Clean Water Act (CWA) Section 401 Water

Quality Certification. Other responsible parties seeking to use the CDF will need to obtain a separate WQMCCP to cover their dredging, transport, and filling activities.

Three types of water quality standards will be employed during CDF construction:

- **Visual Standards.** Continuous visual monitoring of the construction site will be performed for evidence of construction-related impacts. Visual monitoring will be performed during all in-water activities.
- **Conventional Standards.** Turbidity, pH, temperature, and DO will be measured in real time using a field probe, and compared to the water quality standards listed in Table 6-1. Monitoring of conventional parameters will be performed during all in-water activities.
- **Acute Water Quality Criteria.** Laboratory analysis of target metals (i.e., cadmium, lead, and zinc) may be required during demolition of piers and pilings in Slip 1, and analysis of PAHs may be required in the CDF berm key area, if an exceedance of a conventional standard is observed and confirmed in the respective areas. TSS would also be analyzed. Analytical results for metals and PAHs will be compared to the acute water quality criteria listed in Table 6-1. While acute criteria will be used to evaluate compliance with water quality criteria, chronic criteria will be used to evaluate the effectiveness of construction BMPs, and whether additional BMPs should be implemented.

6.1.1.1 Visual Standards

Visual monitoring for water quality impacts during construction activities will take place whenever construction is underway. Visual monitoring will confirm that the construction site meets the following conditions:

- No oily sheen or other visible contamination in the water
- No distressed or dying fish
- No significant turbidity plume outside the compliance boundary

If any of these conditions are observed in the vicinity of construction operations, then a description of the size and probable source of impact must be recorded, and water quality measurements collected. USEPA must be notified to coordinate response decisions.

6.1.1.2 Conventional Standards

The conventional standards that will be used to monitor construction of the T4 CDF are listed below. These standards are consistent with the WQMCCP issued for the T4 Phase I Removal Action (USEPA 2008). Conventional parameters are measured in real time using a multi-parameter field instrument.

Turbidity. State water quality standards allow for limited turbidity exceedances for "dredging, construction, or other legitimate activities" [OAR 340-041-036(b)]. The following turbidity standards will apply at the point of compliance:

- Turbidity shall not exceed 5 Nephelometric Turbidity Units (NTU) above background if background is less than 50 NTU.
- Turbidity shall not exceed 10 percent above background if background is greater than 50 NTU.

At no time should turbidity exceed 50 NTU over background. Should this occur, then all in-water activities shall cease immediately, and USEPA shall be notified. Work shall not resume until turbidity levels have returned to compliant levels and approval has been given by USEPA.

Dissolved Oxygen. At the point of compliance, DO shall exceed 6.5 milligrams per liter (mg/L). At no time should DO drop below 6.0 mg/L at any station. Should this occur, all in-water activities shall cease immediately, and USEPA shall be notified. Work shall not resume until DO levels have returned to compliant levels and approval has been given by USEPA.

pH. At the point of compliance, pH will remain between 6.5 and 8.5 (standard units).

Temperature. At the point of compliance, the 7-day average temperature shall not exceed 18.0 degrees Celsius (°C). When ambient conditions exceed 18.0°C, no temperature increases will be allowed that will raise the receiving water temperature greater than 0.3°C. Should this occur, all in-water activities shall cease immediately, and USEPA shall be notified. Work shall not resume until temperatures have returned to compliant levels and approval has been given by USEPA.

6.1.1.3 Chemical Criteria

Water quality criteria for contingent chemical monitoring parameters are listed below. Laboratory analysis of chemical parameters will be performed in certain areas of the CDF if an exceedance of a conventional parameter is observed at the point of compliance and confirmed to be a result of construction activities. Laboratory analysis will be performed at an off-site analytical laboratory with an accelerated 72-hour turnaround from the time of sample delivery.

Total Suspended Solids (TSS). There are no formal water quality criteria for TSS. However, TSS is potentially a more direct indicator of construction-related sediment resuspension compared to turbidity. TSS is measured in concentration and is, therefore, more relevant for contaminant transport and mass balance calculations, whereas turbidity is a measure of light transmission through the water column.

Acute Metals Criteria. Contingent laboratory analysis of cadmium, lead, and zinc will be performed if an exceedance of one or more field parameters is observed during the demolition of piers in Slip 1. These index metals are associated with historical ore handling at T4. Acute water quality criteria for these metals are derived from Oregon Table 33A (ODEQ 2005) and the USEPA National Recommended Water Quality Criteria (USEPA 2010b). The criteria have been adjusted to a hardness value of 25 mg/L based on average measurements in the Lower Willamette River (USGS Station #14211720). Acute metals criteria will be used to evaluate compliance with water quality criteria, and chronic criteria will be used to evaluate the effectiveness of construction BMPs.

Polycyclic Aromatic Hydrocarbon (PAH) Guidance Values. Contingent laboratory analysis of PAHs will be performed if an exceedance of one or more field parameters is observed during dredging of the berm key. Aquatic life criteria for PAHs are not available in either federal or state standards. However, acute and chronic guidance values for PAHs have been developed by USEPA (USEPA 2003b and Table 6-1). Acute PAH values will be used to evaluate compliance with water quality criteria, and chronic values will be used to evaluate the effectiveness of construction BMPs.

6.1.1.4 Ambient Background Conditions

Ambient background values in the Willamette River for conventional and chemical parameters will be considered in the evaluation of construction monitoring data. No construction-related impacts are indicated if conventional measurements or analytical results are at or below background levels, even if these levels exceed water quality criteria (i.e., when background conditions exceed water quality criteria).

Background conditions in the Willamette River are determined using: 1) the USGS monitoring record at the Willamette River at Portland (Station #14211720); and 2) field measurements and laboratory analytical results at background monitoring stations during the T4 Phase I Removal Action, conducted in August through October 2008 (Anchor QEA 2009). The background values listed in Table 6-1 for conventional and chemical parameters are based on the 90th percentile values of the background dataset.

A background reference station will be established upstream of T4, and this station will be monitored concurrent with the monitoring of CDF construction activities. The background monitoring station will be placed in an area comparable to the compliance locations (e.g., at similar water depths and distances from the shoreline). Ongoing monitoring of this background station will be performed to detect any excursions of ambient river conditions (e.g., excessive turbidity caused by high flow events, etc.) that are not caused by the construction of the CDF, but which may nevertheless affect water quality in the vicinity of the CDF. Ambient background statistics will be regularly updated with the background monitoring data collected during construction.

6.1.2 Short-Term Compliance Boundaries

Compliance boundaries will be established for construction activities. Inside the compliance boundaries, short duration exceedances of the water quality standards (visual, conventional, or chemical) are allowed provided that these exceedances are limited in distance, duration, and magnitude. Water quality standards and criteria as identified herein will be achieved at the compliance boundary. The compliance boundaries are established to allow the construction activities to be implemented while using appropriate BMPs to minimize any short-term impacts to water quality and/or the beneficial uses of the river.

The proposed compliance boundaries for the Slip 1 CDF are:

- <u>Pier Demolition</u>. 100 meters radially from the pier structures in Slip 1 during demolition activities
- <u>Berm Key Excavation, Berm Construction</u>. 100 meters radially from the berm key
- <u>Sediment Offloading</u>. 100 meters radially from the new Berth 405, which will be used to offload barges carrying dredged sediment from other sites in Portland Harbor
- <u>Effluent from the CDF Pond</u>. The CDF pond will be managed such that there will be no direct discharge of effluent into the river; as a result, no compliance boundary is needed.

The configurations of the compliance boundaries are shown in the WQMP (Appendix E).

The boundaries proposed for this project are consistent with those recently applied in other sediment remedial actions in Portland Harbor and in USEPA Region 10, including Phase I of the Removal Action at T4. The boundaries are consistent with state regulations, which allow for limited turbidity exceedances for “dredging, construction, or other legitimate activities” [OAR 340-041-0036(b)].

Dredging elutriate tests (see Section 6.2.1), which are used to evaluate the potential for contaminant releases during dredging, show that dissolved chemical concentrations in the vicinity of the dredge are expected to be undetected, below water quality criteria, or comparable to ambient background levels. Water quality modeling of dredging in the berm key area indicates elevated suspended sediment concentrations will be well controlled, remaining close to the dredge and within the compliance boundaries, and diminishing rapidly with distance from the dredge (see Section 6.3.1). The size of the compliance zones is small enough that the zones will not impede fish migration, given that approximately 80 percent of the width of the river will be unaffected. Very few juvenile salmonids are expected to be in the vicinity of Slip 1 during the construction window, and the few that may travel through the area are not expected to remain near the site for more than 1 day, and more likely a few hours, considering that typical outmigration rates for juvenile salmonids are 8 to 18 kilometers per day (km/day) (ODFW 2005; Knutsen and Ward 1994).

6.1.3 Long-Term Water Quality Criteria

This section provides a review of the long-term water quality criteria that will be used to evaluate groundwater transport through the CDF. A more detailed description of long-term monitoring requirements and activities will be presented in the LTMRP to be submitted as part of the 100 Percent Design.

Final application of ARARs related to surface water will be established by USEPA for the Portland Harbor Superfund Site in the ROD, currently estimated in December 2012. As a result, how the water quality standards and associated performance standards are applied to the CDF will be finalized at that time. For the purposes of this 60 Percent DAR, the long-term water quality numeric criteria and associated performance standards outlined in USEPA's letter to the LWG, dated February 18, 2010, are used (USEPA 2010a). As directed by USEPA, the numeric criteria are applied without dilution in the water column; i.e., at an observation point inside the berm (not including the riprap face). These criteria are summarized below. Although the 60 Percent CDF DAR is based on the USEPA-directed performance standards, other information on how numeric water quality criteria are applied for implementing all water quality standards is provided for additional context.

6.1.3.1 Chronic Ambient Water Quality Criteria

Chronic ambient water quality criteria provide a surface water concentration considered safe for aquatic organisms over a 4-day exposure period. The chronic criteria for copper, DDx, and Total PCBs are from Oregon Table 33A (ODEQ 2005) and the USEPA National Recommended Water Quality Criteria (USEPA 2010b). The chronic guideline values for naphthalene and benzo(a)pyrene are from USEPA guidance (USEPA 2003b).

6.1.3.2 Fish Consumption Criteria

A key exposure pathway for the Portland Harbor Site is the potential for contaminants to bioaccumulate in fish and shellfish at levels that could pose a risk to humans that consume fish and shellfish from the harbor. Human health criteria for fish consumption used for the T4 CDF design are the National Recommended Water Quality Criteria (USEPA 2010b). Fish consumption criteria for dioxin-like PCB congeners are derived from the criteria for 2,3,7,8-TCDD (dioxin) and USEPA's recommended toxicity equivalency factors (USEPA 2009b).

During USEPA and LWG clarifications of the USEPA CDF performance standards (LWG 2010a and 2010b), it was agreed that spatial averaging of concentrations over the area of the berm face would be appropriate for evaluating fish consumption criteria in groundwater exiting the CDF. This is a conservative approach because considerably larger exposure scales, consistent with the home range of the fish and the harvesting area of the fishers, are likely appropriate (USEPA 2006b). It is also appropriate to temporally average fish consumption exposures over the human lifetime (i.e., 70 years) (USEPA 1991; ODEQ 2007; LWG 2008a).

6.1.3.3 Drinking Water Criteria

The Safe Drinking Water Act has been determined by USEPA to be potentially relevant and appropriate to the CDF. The USEPA CDF performance standards include a comparison of groundwater concentrations exiting the CDF to drinking water MCLs (USEPA 2009b). The exact application of drinking water criteria as an ARAR for a CDF will be determined by the Portland Harbor ROD.

6.1.3.4 Ambient Background Concentrations

Characterization of upstream background concentrations in the Willamette River should be considered in long-term water quality evaluations because it is impracticable to control CDF groundwater concentrations to levels below ambient background concentrations in the river. Similarly, it is impracticable to impose water quality compliance criteria lower than ambient background concentrations in the river. High-volume surface water samples collected at upstream locations in Portland Harbor were used to define ambient background concentrations of Portland Harbor COCs, especially bioaccumulative COCs (LWG 2009; Table 7.4-4).

6.1.3.5 Limits of Analytical Technology

Compliance decisions cannot reliably be made at concentrations below the limits of analytical technology. In the USEPA letter dated November 15, 2007, regarding Resolution of 60 Percent Design Disputed Comments on the T4 Removal Action (T4 Dispute Resolution Agreements), the Port and USEPA agreed that *"…currently available laboratory quantification limits and their ability to achieve all standards (especially human health criteria) is an issue that needs to be resolved as part of the 100% Design."* To that end, analytical reporting limits were considered in the evaluation of groundwater quality exiting the CDF. Analytical reporting limits were taken from the Quality Assurance Project Plan for the LWG Round 3A stormwater sampling event, based on low-level analytical methods and standard sample volumes (LWG 2007).

6.1.3.6 Total Maximum Daily Loads

Currently, there are four total maximum daily loads (TMDLs) in effect in the Lower Willamette River:

- Temperature
- Bacteria
- Mercury

- Dioxin

None of these TMDLs are relevant to groundwater quality in the CDF. Groundwater exiting the CDF is not a source of elevated temperature or bacteria. The dioxin TMDL, approved in 1991 for implementation in the Columbia River Basin including the Lower Willamette River, is primarily directed at chlorine-bleaching pulp and paper mills, none of which are present in Portland Harbor. Significant secondary dioxin sources, such as non-chlorine bleaching pulp and paper mills and municipal wastewater treatment plants, are also absent from the Harbor, and the historical pentachlorophenol-based wood treating site in the Harbor (McCormick and Baxter site) was the subject of a separate ROD and cleanup action.

Mercury is not a significant COC in dredged material being placed in the CDF, considering that mercury was detected in only one out of 40 leachate cycles from high-priority AOPCs in Portland Harbor. Nevertheless, the potential mercury load from the CDF was evaluated in the previous T4 design submittal to ensure that the CDF is protective and will comply with the Portland Harbor ROD (Anchor 2006b). ODEQ adopted an interim TMDL for mercury in September 2006. The interim TMDL determined that an overall loading reduction of 27 percent from all source categories (point source and nonpoint source) would reduce annual mercury inputs to an acceptable guidance level of 94.6 kilograms per year (kg/yr). ODEQ's implementation strategy for the interim mercury TMDL includes point and nonpoint source reductions focused on wastewater discharges, air emissions, and minimizing soil erosion in areas that contain naturally occurring mercury. ODEQ does not plan to establish waste load allocations or load allocations for mercury until approximately 2011.

For the purpose of this analysis, it was assumed that mercury is present in dredged material leachate at the laboratory reporting limit (0.1 μg/L), given that mercury was undetected in 39 out of 40 leachate analyses. The reporting limit was used as the initial concentration in groundwater modeling predictions. At the time when peak mercury concentrations are reached, which would not be for several centuries, the estimated annual mercury load in groundwater exiting the CDF was estimated to be less than 0.0002 kg/yr. This load is nearly a million times less than the acceptable guidance level of 94.6 kg/yr; i.e., it is negligible and, therefore, will not adversely impact the mercury TMDL and the associated source reduction plan.

6.1.3.7 303(d) Listings

In addition to the TMDLs discussed above, several other chemicals have been placed on the State 303(d) list. The following 303(d)-listed chemicals were specifically evaluated in the T4 CDF groundwater model (see Appendix A):

- DDT/DDE (as DDx)
- PCBs
- PAHs

In addition, the T4 CDF groundwater model also addresses the intent of the "Biological Criteria" listing, which is based on "fish exceeding EPA's human health screening values," given that compliance with fish consumption criteria is an integral part of the CDF evaluation. The remaining chemicals on the State 303(d) list are of secondary importance in Portland Harbor (i.e., DO, aldrin, dieldrin, and pentachlorophenol), or are dominated by background contributions from native basaltic rock (i.e., iron, manganese, and arsenic). Other parameters listed for potential concern include hexavalent chromium, lead, copper, nickel, zinc, malathion, parathion, DDD, and certain specific PAHs (i.e., fluoranthene, chrysene, benzo[a]pyrene, and benzo[a]anthracene).

6.1.4 Long-Term Points of Compliance

The USEPA CDF performance standards require that groundwater exiting the CDF be compared to surface water criteria in the porewater of the berm, without dilution in the water column (USEPA 2010a). USEPA is allowing the LWG and the Port to propose alternative groundwater discharge performance standards and points of compliance to better understand the implications (including cost and effectiveness) of the USEPA CDF performance standards.

6.2 Contaminant Mobility Testing

Contaminant mobility testing results are described in this section. DRETs were performed to assess short-term water quality effects during dredging, and SBLTs were performed to assess long-term effects on CDF groundwater quality.

6.2.1 Dredging Elutriate Tests

DRETs were performed on two representative composite samples at T4. One composite sample (T4-CM1) includes sediment from Slip 1 and Berth 401, and the other composite sample (T4-CM2) includes sediment from Slip 3, Berth 414, and Wheeler Bay.

The DRET results for the composite samples T4-CM1 and T4-CM2 show that water quality effects from sediments resuspended during dredging will be negligible (Table 6-2 and BBL 2005). All metals results were well below their respective acute water quality criteria, with the exception of copper. One of the two DRET copper concentrations (5.1 and 4.3 μg/L in composite samples T4-CM1 and T4-CM2, respectively) was slightly above the acute copper criterion (4.4 μg/L) [Note: the acute and chronic copper criteria were calculated using the Biotic Ligand Model and major element chemistry in the Willamette River based on the USGS monitoring record at Portland Oregon, Station #14211720]. However, similar concentrations have been reported in ambient background surveys in the Willamette River (ODEQ 2002), and the copper concentrations in the bulk sediment samples (23 and 26 milligrams per kilogram [mg/kg], respectively) are within the range of background soil concentrations in the Pacific Northwest (WDOE 1994). Only a few PAHs were detected, and the few detected PAHs were two or more orders of magnitude below their acute water quality guidance values (USEPA 2003b). No DDT isomers or PCBs were detected.

Dredging of the berm key will be performed during construction of the CDF. The average sediment concentrations in the berm key overexcavation area (comprised of the 0 to 5-foot intervals in four cores in the berm footprint) are compiled in Table 6-3. The quality of the sediment in the berm key area is very consistent with the quality of sediment used in DRET tests T4-CM1 and T4-CM2; therefore, the results of the DRET tests, as summarized above, should be representative of berm key dredging activities.

The results of the construction water quality monitoring program implemented during the Phase I Removal Action at T4, Slip 3 (Anchor QEA 2009) provide further evidence that no adverse water quality effects are expected during berm key dredging. The entire Phase I Removal Action in Slip 3 was implemented with only one exceedance of a conventional standard (turbidity) related to dredging at Berth 414, and no exceedances of chemical water quality criteria (including metals, PAHs, PCBs, and DDTs). As shown in Table 6-3, sediments in the Phase I Removal Action area, which were safely dredged with no significant exceedances of water quality criteria, are much more contaminated than sediments in the berm key area. Metals, DDx, and PCB concentrations in Slip 3 are several times higher than those in the berm key area, and lead and PAH concentrations are more than ten times higher than the berm key area.

6.2.2 Modified Elutriate Tests and Column Settling Tests

METs are designed to predict the chemical quality of dredging elutriate water flowing over the weir of the CDF during hydraulic filling. CSTs are designed to predict the amount of turbidity and suspended solids that discharge over the weir of the CDF during hydraulic dredging and filling. If hydraulic dredging is determined to be a practicable and cost-effective alternative for a particular AOPC, and weir overflow is predicted to occur, METs and CSTs will be conducted on a site-specific basis during later stages of design. However, this is not anticipated to be a pathway of concern for this project (see Section 6.3.1).

6.2.3 Sequential Batch Leaching Tests

SBLTs are laboratory tests designed by USACE to simulate chemical leaching characteristics of sediments in a CDF (USACE 2003) and, in this case, the leachability of COCs in Portland Harbor dredged sediments after placement in the T4 CDF. These data are used to initialize the source concentrations in the CDF groundwater model. The groundwater model then describes the attenuation processes that occur as the COCs migrate through the CDF toward the river.

The LWG performed SBLT testing on composite sediment samples from 11 AOPCs within Portland Harbor (LWG 2009). An SBLT test was also performed by the Port using composited sediment from T4. In all, bulk sediment and leachate data are available for 12 AOPCs, which are among the sites most likely to be addressed with active remediation, including dredging. These AOPCs provide a representative cross-section of contaminated sediments throughout Portland Harbor, extending from RM 2.2 to RM 9.7 on both the east and west banks of the river, and including a wide spectrum of waterfront industries and COCs.

Four sequential leachate cycles were extracted and analyzed for each AOPC. A summary of bulk sediment and mean leachate quality for CDF index contaminants (copper, naphthalene, benzo[a]pyrene, DDx, and Total PCBs) in each of the 12 AOPCs is provided in Table 6-4. The organic contaminants are sufficiently hydrophobic that there is negligible change in the bulk sediment concentration between leachate cycles; therefore, decreasing concentrations were not normally observed across the four leaching cycles. Further discussion of SBLT results is provided in Appendix A, Attachment 1 of the Groundwater Model Input Parameter Memorandum.

The SBLT tests are also used to develop partitioning coefficients for contaminated sediments from Portland Harbor, as described in Section 6.4. The partitioning coefficients describe how readily contaminants are desorbed from the sediments, dissolved in groundwater, and transported through the CDF.

Ten of the AOPCs were evaluated for placement in the T4 CDF. Statistical distributions of leachate concentrations and partitioning coefficients were compiled on a Harbor-wide basis using the SBLT results from these ten AOPCs. The remaining two AOPCs (Sites 9 and 14, adjacent to Gasco and Arkema, respectively) were excluded from the Harbor-wide analysis because portions of these AOPCs may contain free product. Sediments containing free product may require stabilization or some other form of treatment before they are considered suitable for placement in the CDF. Therefore, additional work at Sites 9 and 14 would be necessary to determine whether portions of these AOPCs could be placed in the CDF.

The groundwater modeling results indicate that dredged sediments from the ten AOPCs would be suitable for placement in the T4 CDF. The groundwater modeling results are discussed in Section 6.4 and Appendix A.

6.3 Short-Term Water Quality Effects

6.3.1 Water Quality during Dredging

A number of factors influence water quality conditions around the dredging operations. These factors include dredging equipment and methods, sediment characteristics, hydrodynamic conditions, water depth, and others. Mechanical dredging will be utilized to excavate the berm key.

The USACE model DREDGE was used to predict suspended sediment concentrations around the dredging operation (Kuo and Hayes 1991). DREDGE model input parameters are summarized in Table 6-5. A mechanical simulation was performed using input parameters representative of the berm key area (i.e., current velocity, water depth, and sediment gradation). The loss rates for mechanical dredging were estimated to range from 5 to 10 percent loss.

DREDGE model results are shown on Figure 6-1. The model-predicted TSS concentrations in the immediate vicinity of the dredge are as high as 26 to 54 mg/L. Concentrations drop off rapidly within a short distance from the dredge. The DREDGE model estimates TSS concentrations typical of ambient conditions in the Willamette River (22 mg/L; USGS 2006) will be reached within 10 meters.

Dredging BMPs to protect water quality and minimize turbidity are presented in the WQMP (Appendix E) and the Construction Specifications (Appendix C).

6.3.2 Water Quality during Berm Construction

The new containment berm will be created by placing material across the mouth of Slip 1 and parallel to the riverbanks, for a total distance of approximately 600 horizontal feet. The height of the berm will be equivalent to the height of the adjacent riverbanks at an elevation of approximately 30 to 35 feet NGVD. The berm will be approximately 300 feet wide at the base and 20 feet wide at the top.

Increased turbidity and suspended sediment concentrations may occur during placement of berm material through the water column, including placement of training terraces and select fill material. Water quality monitoring (i.e., visual, conventional, and contingent laboratory analysis) will occur at the mouth of Slip 1 during berm construction. Further details are provided in the WQMP (Appendix E). Appropriate construction BMPs are presented in the Construction Specifications (Appendix C).

6.3.3 Water Quality during Filling of the CDF

Hydraulic dredging and filling may not be a feasible option for most or all of the AOPCs in Portland Harbor, given that most of the AOPCs are located a long distance from T4, and many are on the opposite bank of the river. It is expected that a majority of the sediments AOPCs will be mechanically dredged and barged to the CDF. Mechanically dredged and barged sediments will then either be mechanically transferred over the berm, or hydraulically transferred with a high-solids pump using pond water as make-up water. In either case, there will be no significant rise in the pond level of the CDF, and no overflow or effluent discharge to the river. Therefore, this is not a pathway of concern for this project.

6.3.4 Water Quality during Sediment Transport

Dredged sediment will be transported by barge and/or hydraulically through a pipeline from the dredging location to the CDF. Sediment overexcavated beneath the containment berm will be dredged mechanically and transported by barge to the head of Slip 1 for placement. It is expected that barge transport will be used for the majority of AOPCs in Portland Harbor that would potentially be using the CDF.

Water quality monitoring (visual, conventional, and contingent laboratory analysis) will occur at the transfer facility if the material is mechanically offloaded, and along the pipeline if the material is hydraulically dredged. Further details are provided in the WQMP (Appendix E). Appropriate construction BMPs are presented in the Construction Specifications (Appendix C).

6.3.5 Water Quality during Demolition and Pile Removal

Numerous structures and piling will be demolished and removed in Slip 1 as part of CDF construction. Possible water quality impacts during demolition and pile removal activities include generation of debris and dust, and disturbance of sediment. Water quality monitoring (visual, conventional, and contingent laboratory analysis) will occur at the demolition site. Further details are provided in the WQMP (Appendix E). Appropriate construction BMPs are presented in the Construction Specifications (Appendix C).

6.3.6 Water Quality during Marine Structures Construction

Piling will be driven and superstructure constructed as part of the installation of the new Berth 405. Water quality monitoring (visual, conventional, and contingent laboratory analysis) will occur at the construction site. Further details are provided in the WQMP (Appendix E). Appropriate construction BMPs are presented in the Construction Specifications (Appendix C).

6.4 Long-Term Groundwater Quality in the CDF

A CDF groundwater contaminant transport model was developed to simulate leaching of COCs from dredged sediment placed in the CDF, and subsequent transport of COCs through the berm and the underlying aquifer toward the Willamette River. A two-dimensional cross-sectional model was aligned with the critical groundwater flow path through the center of the CDF. The following contaminant transport and attenuation processes are included in the model:

- Groundwater advection and dispersion
- Mixing of leachate with incident rainfall above and regional groundwater below
- Adsorption and desorption of contaminants onto berm and aquifer matrix materials
- Biodegradation of contaminants (in some scenarios)

Visual Modflow (Version 2010.1 Pro, Build 4.5.0.157, Waterloo Hydrogeologic, Inc.) was used for model construction, execution, and visualization. All groundwater flow simulations were performed with MODFLOW-2000 (Harbaugh et al. 2000). Contaminant transport simulations were performed with MT3DMS (Zheng and Wang 1999), which uses the flow solution provided by MODFLOW-2000.

Documentation of model input parameters, set up, calibration, results, and sensitivity analysis are provided in Appendix A, and described briefly below.

6.4.1 Groundwater Model Input Parameters

Physical and hydrogeologic input parameters are compiled in Table 6-6, including mean or central tendency values for use in base case model simulations, and a representative range of values (minimum and maximum values) for use in sensitivity and uncertainty analysis. Geochemical input parameters for T4 CDF COCs are compiled in Table 6-7. Data sources and rationale are also summarized in these tables. An overview of key model input parameters is provided below. A more detailed discussion is provided in Appendix A – Groundwater Model Input Parameter Memorandum.

6.4.1.1 Hydrogeologic Parameters

The material and hydraulic properties of the CDF building materials, including the contaminated sediment fill material, cover material (imported fill), regional aquifer, berm fill, and the training dikes are summarized in Table 6-6. Representative values for organic carbon content for contaminated sediment fill material were derived from bulk sediment testing of Portland Harbor AOPCs (LWG 2009). Representative values for organic carbon content for import fill and berm fill material were derived from test results from local quarries (Anchor 2007b). Hydraulic conductivity values for contaminated sediment fill material were derived from consolidation tests conducted at T4 and other Region 10 sites; these tests simulate the reduction in porosity and permeability that result from the self-weight and overburden pressures in a CDF (Anchor 2007c). Hydraulic conductivity values for local aquifer materials were derived from T4 pumping tests (Hart Crowser 2000), and representative literature values were used to characterize import fill and berm fill material based on their grain size specifications (Freeze and Cherry 1979). Values for horizontal and vertical dispersion were obtained from dynamic model calibration, which is driven by daily and seasonal water level fluctuations in the river (NewFields 2007a).

6.4.1.2 Initial Source Concentrations

The initial source concentrations for the various groundwater COCs are compiled in Table 6-7. The geometric mean, arithmetic mean, and 90th percentile leachate concentrations from Portland Harbor SBLT results (excluding leachate results from AOPCs 9 and 14; see Section 6.2.3) were selected to represent the initial conditions in the groundwater model, including the base case (central value), as well as the range of concentrations (minimum and maximum values) to use in the sensitivity and uncertainty analysis. Because the CDF is comprised of a mixture of sediment and leachate from a variety of different AOPCs, an average concentration (i.e., arithmetic mean) is an appropriate statistic to characterize the source strength of this material. This does not suggest that the sediments will be homogeneously mixed during placement, but rather that CDF groundwater will be exposed to sediments from a variety of different AOPCs as it migrates through the CDF. In the future, more specific placement scenarios may be evaluated, which could consider volume-weighted averaging of AOPC leachate quality. However, information on the comparative removal volumes of the AOPCs and the sequencing of remediation actions in the Harbor is not currently available.

6.4.1.3 Partitioning Coefficients

The ratio of the bulk sediment concentration to the SBLT leachate concentration is used to develop site-specific partitioning coefficients for contaminated sediment placed in the CDF. The partitioning coefficient describes how readily contaminants are desorbed from the sediments, dissolved in groundwater, and made available for transport through the CDF. The derivation of partitioning coefficients from SBLT tests is presented in Appendix A, Attachment 1 of the Groundwater Model Input Parameter Memorandum. For most constituents, the geometric mean value of the partitioning coefficients from the ten Portland Harbor AOPC sites was used as the base case value; for Total PCBs, the coefficient was derived from a linear isotherm model (see Appendix A, Attachment 1 of the Groundwater Model Input Parameter Memorandum for further details). The initial source concentrations and the partitioning coefficients are dependent variables in that both are derived from the same SBLT leachate data; therefore, the model sensitivity analysis was focused on the variability in initial source concentrations, those being the more direct measurements, rather than the variability in partitioning coefficients.

The SBLT leachate results are applicable to the contaminated sediment material, but are not representative of the geochemical environment in the berm. The physical properties (sand and gravel) and source characteristics (regional quarries) of the berm material are fundamentally different, as are the geochemical conditions in the berm (i.e., dominated by adsorption processes rather than desorption). Applicable partitioning coefficients for metals in the berm material were established in NewFields (2007b). Partitioning coefficients for organic constituents were adopted from the LWG RI Report, Table E6 (LWG 2009). The minimum Koc value for DDD was revised based on site-specific Willamette River water column data.

6.4.1.4 Biodegradation Rates

Biodegradation rates used in the T4 CDF model (expressed as half-lives, in days) are presented in Table 6-7, along with supporting literature citations. It is expected that anaerobic degradation processes will prevail in the confined contaminated sediments, whereas aerobic degradation processes will be more important in the berm. The T4 CDF model assumes zero degradation as a base case and worst-case scenario, and also provides alternative scenarios with conservatively protective biodegradation rates from the lower end of published literature values, (i.e., slower rates), with particular emphasis on field and regional studies.

PAHs. Anaerobic biodegradation rates for PAHs were compiled from the published literature based primarily on laboratory measurements on sediments and sediment slurries from freshwater, estuarine, and marine environments (Bach et al. 2005; Coates et al. 1996a, 1996b, and 1997; Chang et al. 2001; Heitkamp and Cerniglia 1987; and Rothermich et al. 2002). Rates measured in liquid media and tests inoculated with microorganisms were not included. Because chemical metabolism depends on bioavailability and, more specifically, solubility in porewater, the published biodegradation rates were normalized to the porosity and organic carbon content (1.5 percent) of the Portland Harbor dredged sediments. A regression model was developed which correlated the molecular weight of the PAH compounds to the normalized, published biodegradation rates, given that higher molecular weight PAHs degrade more slowly than lower molecular weight PAHs (Cerniglia 1992). The biodegradation rate defined by the 5 percent lower confidence level of the regression model was calculated, and this was further reduced by a factor of ten to provide an additional layer of conservatism and to account for possible overestimation of biodegradation rates in laboratory experiments. Based on this analysis, the biodegradation half lives for naphthalene and benzo(a)pyrene were conservatively estimated at 3 years and 40 years, respectively.

DDx. Biodegradation of DDx compounds, primarily DDE, has been extensively studied on the Palos Verdes shelf off southern California, which received contaminated effluent discharges from a nearby Montrose Chemical plant. In anaerobic sediments, DDE is the most resistant of the DDx isomers to biodegradation (Huang et al. 2001). Sediment investigations showed that the DDE mass inventory on the Palos Verdes shelf was reduced by approximately 50 percent in 10 to 15 years (Eganhouse et al. 2000a; Quensen et al. 2001), indicating significant transformation of DDE was occurring. Eganhouse et al. (2000a) estimated DDE biodegradation rates on the Palos Verdes shelf based on an analysis of parent and degradation products in core profiles; their estimated half lives ranged from 30 to 300 years, with a geometric mean of 90 years. They suggested that physical-chemical processes, such as porewater diffusion, resuspension, and advection out of the study area, accounted for the much higher DDE loss rates that were observed in the field. In contrast, higher degradation rates were measured in laboratory studies of Palos Verdes shelf sediments, with DDE half lives ranging from about 1 to 10 years with a best estimate of 7 years (Quensen et al. 2001). In consideration of these studies, a conservative DDx half life of 90 years was selected for use in the T4 CDF model.

PCBs. A number of field studies have shown that PCBs undergo significant dechlorination in anaerobic environments over periods of a few decades, causing an overall reduction in the molecular weight of the PCB mixture and a shift toward simpler and less chlorinated homologs (Magar et al. 2005; van Dort et al. 1997). The dechlorination process is beneficial in several ways: it provides a direct reduction in PCB mass and concentration through the loss of chlorine atoms, a general detoxification of the mixture through transformation to less toxic congeners, and it leads to the formation of simpler and lighter PCB molecules that are more susceptible to aerobic degradation (i.e., destruction), which can occur in the CDF berm. Other studies have shown that highly toxic, dioxin-like PCB congeners are preferentially attacked during anaerobic dechlorination, leading to a substantial reduction in PCB toxicity in only a decade or two (Beurskens and Stortelder 1995; Sinkkonen and Paasivirta 2000). For example, the degradation half life of PCB-126, which accounts for about 86 percent of the dioxin-like toxicity in Portland Harbor leachate samples, was estimated at only 6.5 years in buried sediments from the Rhine River (Beurskens and Stortelder 1995). Long-term regional models for evaluating the environmental fate of PCBs in both San Francisco Bay and Lake Ontario used a PCB degradation half life in aquatic sediments of 56 years (Davis 2004; Gobas et al. 1995). In consideration of these studies, a PCB half life of 60 years was selected for use in the T4 CDF model.

6.4.2 Long-Term Groundwater Model Results

Figures 6-2A through 6-2E present the predicted CDF groundwater exit concentrations for a list of key Portland Harbor COCs, including copper, naphthalene, benzo(a)pyrene, DDx, and

Total PCBs, respectively. These charts show the model prediction curves for the 1,000-year simulation periods. By comparison, the longest applicable engineering design standard being applied to the CDF (the seismic design standard) has a return period of 475 years. Except for naphthalene, which peaked and decayed much more quickly than the other COCs, the model-predicted concentration trends were relatively stable at the end of the 1,000-year simulation period.

Model predictions are compared to various regulatory criteria, including chronic aquatic life criteria, fish consumption criteria, and drinking water MCLs, as required by the USEPA CDF performance standards (USEPA 2010a). Ambient upstream background concentrations in the Willamette River, and laboratory analytical limits (below which concentrations cannot be reliably quantitated) are also shown, as both must be considered in compliance evaluations. Prediction curves are presented for the peak centerline concentration, as well as the spatially averaged concentration over the interface between the berm and the river. Peak concentrations are appropriate for evaluating chronic risk to aquatic life, and spatially averaged concentrations are appropriate for evaluating fish consumption risk to humans. The region at or below analytical reporting limits is shaded in gray, and the region at or below ambient background concentrations is shaded in yellow. For organic constituents, model predictions are presented for a scenario with no biodegradation and an alternative scenario assuming a conservatively slow rate of biodegradation based on peer-reviewed literature studies (see Section 6.4.1.4).

Copper (Figure 6-2A). Centerline copper concentrations are below both chronic water quality criteria and upstream background concentrations during the 1,000-year model simulation period. Therefore, no adverse effects are predicted for copper.

Naphthalene (Figure 6-2B). Centerline naphthalene concentrations remain well below the chronic guideline indefinitely. This result was anticipated prior to conducting the model simulation since the initial leachate concentration was already below the chronic guideline. Naphthalene concentrations are also predicted to remain below the analytical reporting limit. Therefore, no adverse effects are predicted for naphthalene. Note that naphthalene prediction curves were terminated early because concentrations had already reached their maximum value and were declining, due to naphthalene's low partitioning coefficient.

Benzo(a)pyrene (Figure 6-2C). The benzo(a)pyrene centerline concentration remains well below the chronic guideline, and the spatially averaged concentration remains well below the MCL and fish consumption criteria during the 1,000-year model simulation period. The model predicted concentrations are also below the analytical reporting limit. Therefore, no adverse effects are predicted for benzo(a)pyrene. For comparison, model predictions using a conservative biodegradation rate (41-year half life) are also presented; when biodegradation is considered, benzo(a)pyrene concentrations are many orders of magnitude below all water quality criteria.

DDx (Figure 6-2D). The DDx centerline concentration remains below the chronic water quality criteria, and the spatially averaged concentration remains below the fish consumption criteria during the entire 1,000-year simulation period. The model predicted concentrations are also below the analytical reporting limit. Therefore, no adverse effects are predicted for DDx. For comparison, model predictions using a conservative biodegradation rate (90-year half life) are also presented; when biodegradation is considered, DDx concentrations are many orders of magnitude below all water quality criteria.

Total PCBs (Figure 6-2E). Total PCB centerline concentrations remain well below the chronic water quality criteria, and spatially averaged concentrations remain well below the MCL during the entire 1,000-year simulation period. Spatially averaged PCB concentrations also remain below the fish consumption criterion for approximately 500 years, assuming zero biodegradation, and below the upstream background concentration and the analytical reporting limit for approximately 600 years. Model predictions using a conservatively slow biodegradation rate (60-year half life) indicate Total PCB concentrations are orders of magnitude below all water quality criteria at all times. With a biodegradation half life as long as 205 years (i.e., more than three times the recommended value of 60 years), the Total PCB concentrations in groundwater exiting the berm will meet water quality criteria indefinitely. Therefore, no adverse water quality effects are predicted for Total PCBs.

Contaminant Transport Pathways. The contaminant distributions and transport pathways for DDx and PCBs in groundwater migrating through the CDF berm at Year 475 are shown on Figure 6-3. Although the absolute concentrations and travel times will differ, the relative distributions and pathways will be similar for other COCs as well since they are fundamentally controlled by the same processes. In general, the fine-grained and compacted dredged sediment in the CDF serves as a plug, causing regional groundwater to flow around and under the facility, and then upwell into the more permeable berm. Contaminants diffuse out from the contaminated sediment along the base of the CDF and along the inner berm face, and they are then advected toward the river with the upwelling regional groundwater flow regime. The training dikes provide preferential transport pathways across the berm, being an order of magnitude more permeable than the berm fill. As a result, the leading edge of the groundwater plume, as well as the peak concentrations, occur within the upper training dike on the outer berm face. Long-term groundwater monitoring efforts should therefore be focused on characterizing this critical pathway.

6.4.3 Groundwater Model Sensitivity and Uncertainty

6.4.3.1 Model Sensitivity Analysis

Model sensitivity analysis was conducted to determine which input parameters have the greatest effects on model predictions. In some cases, model results were not particularly sensitive to the observed ranges in input parameter values. Model results were less than +2.4 times the base case concentration as a result of variability in sediment fill permeability, berm permeability, and berm foc. A moderate degree of sensitivity was observed for contaminated sediment source concentrations (i.e., leachate concentrations). Model predictions varied by up to +2.5 times and -4.1 times the base case concentration as a result of variability in the source strength of PCBs and DDx.

A higher degree of sensitivity was observed for berm Koc values; in particular, significantly higher concentrations were observed for Total PCBs (+ 35 times) and DDx (+ 300 times) at Year 475 when minimum Koc values were applied. However, other lines of evidence, including Willamette River surface water data (i.e., analysis of particulate and dissolved fractions), indicate such low Koc values are not representative of Portland Harbor sediments, and the mean Koc values selected for the T4 CDF base case simulations are appropriate. The most sensitive input parameter is the biodegradation rate. By assuming zero biodegradation, predicted concentrations of Total PCBs and DDx may be overestimated by two to three orders of magnitude.

6.4.3.2 Model Uncertainty Analysis

An uncertainty analysis was conducted to assess the robustness of the CDF groundwater model predictions. The uncertainty analysis was focused on variability in source concentrations and berm Kd/Koc values because model results were shown to be highly sensitive to these input parameters. Relatively extreme observations were evaluated. Source concentrations were varied between the 50th and 90th percentiles of the Portland Harbor leachate data, and berm Kd/Koc values were varied between the minimum and maximum reported literature values (outliers removed), as compiled in the Portland Harbor RI Report, Table E6 (LWG 2009). Model predictions for copper, benzo(a)pyrene, DDx, and Total PCBs were evaluated. A conservatively slow biodegradation rate was assumed for organic COCs.

The results of the uncertainty analysis are shown in Figures 6-4A through 6-4D. For the organic COCs, the model results were much more sensitive to variability in Koc values compared to source concentrations. In all scenarios and for all COCs, the model-predicted peak concentrations were below all applicable water quality criteria. These results demonstrate that model predictions are robust to input parameter assumptions and provide further evidence that the CDF will be protective of water quality in the river.

6.4.3.3 Other Potential Uncertainty Factors

Conservative Exposure Assumptions. One of the most conservative model assumptions is the application of spatially averaged receiving water criteria, specifically fish consumption criteria, to the porewaters beneath the berm face. Rapid initial mixing in the receiving water will cause significant attenuation of contaminant concentrations; i.e., reductions of several orders of magnitude immediately after groundwater exits the berm, because the groundwater seepage rate (8.9 E-7 meters per second [m/sec]) is approximately 50,000 times slower than the ambient river velocity (5 E-2 m/sec). The effect of CDF groundwater on receiving water quality at 10 cm from the berm face is unmeasurable. Mass balance calculations show no discernible change in the ambient background concentrations in the river as a result of groundwater discharge from the CDF. By applying receiving water standards to the berm porewater, groundwater model predictions are extremely protective of the receiving water, where the real aquatic exposures occur, by several orders of magnitude.

Turbid Leachate Samples. The SBLT leaching tests used to characterize the source strength of the porewaters of the contaminated dredge fill are susceptible to high biases. Fine clay particles and colloids have the ability to pass through the filtration step of the SBLT, especially the nonstandard 1-micron filter used for organic constituents. Laboratory observations of high turbidity levels in the filtered leachate support the interpretation that SBLT results may be biased high due to the inclusion of excessive particulate matter. Partitioning coefficients derived from turbid SBLT results are typically one to two orders of magnitude lower than corresponding literature values, indicating the magnitude of the bias may be significant. This provides a factor of conservatism in groundwater model predictions.

Porewater Release During Dredge Sediment Consolidation. A possible source of model uncertainty is the degree to which contaminant transport might be accelerated as a result of porewater being expelled during dredge sediment consolidation. If so, model predictions could underestimate the travel times of contaminants. The mean residence time of groundwater in the CDF is approximately 50 to 100 years (see Appendix A, Figure 5A). In other words, a pore volume in the CDF will turn over once every 50 to 100 years, on average. Even if an entire pore volume was expelled instantaneously, due to compaction, it would only accelerate the groundwater travel time by about 10 percent over the 500- to 1,000-year model simulation period. Therefore, the net effect of porewater expulsion during consolidation is not likely significant over the time scale of interest.

Preferential Transport along Thin Sand Layers. Thin (approximately 6-inch-thick) sand layers may be applied during the filling of the CDF to provide an interim cover over contaminated dredged material between filling seasons. A possible source of model uncertainty is the degree to which these sand layers might cause preferential flow paths through the CDF. Because of their limited thickness, the likelihood of being mixed with underlying and overlying fine-grained sediment during filling, and the likelihood that the layers will be broken into discontinuous lenses during consolidation, preferential flow seems unlikely. Further evaluation of potential thin sand layers will be conducted during 100 Percent Design when the use and configuration of such layers is better understood.

Competitive Sorption Effects. In laboratory studies, co-solutes have been observed to compete for available adsorption sites (Faria and Young 2010; Crittenden et al. 1985). The degree of competition depends on the nature of the organic substrate and the physical-chemical properties of the contaminants. Structurally similar molecules appear more likely to exhibit competition. DDx and PCBs have similar molecular weight (354 and 326 g/mol for DDT and Aroclor 1254, respectively) and similar partitioning behavior (log Koc values of 6.44 and 6.39, respectively; Table 6-7), and may therefore exhibit competitive adsorption in the T4 CDF berm.

Because the average PCB concentration in CDF leachate is about 15 times higher than the average DDx concentration, competitive sorption by DDx is likely to have an insignificant effect on the fate and transport of PCBs. On the other hand, the adsorption of DDx could potentially be reduced by as much as an order of magnitude due to the greater prevalence of PCB molecules on the adsorption sites, leading to faster travel times for DDx. Even considering such an effect, however, DDx would not exceed fish consumption criteria in porewater for well over 500 years, without assuming biodegradation.

6.5 Other Design Considerations Affecting CDF Groundwater Quality

6.5.1 Berm Material Permeability

In response to a USEPA request, further evaluation was conducted on the potential of using finer-grained material within the berm to reduce the permeability and further reduce groundwater concentrations exiting the berm, even though CDF model predictions indicate long-term groundwater quality will be in compliance with water quality standards. The selection of the berm material is a balance between finding the lowest permeable material that will not adversely affect the seismic stability of the berm. Finer-grained material will have a lower shear strength and, hence, is less resistant to failure during a seismic event.

A sensitivity analysis was completed on locally available fill materials. Ten different materials from four different suppliers were evaluated to estimate both their permeability and the seismic stability of the containment berm if it were constructed of those materials. Figure 6-5 plots the results of the sensitivity analysis. The y-axis of the graph represents the seismic safety factor for the material. For design purposes, a safety factor greater than 1.1 is acceptable. The x-axis represents the grain size of the material. Specifically, it represents the D_{10}, which corresponds to the grain size below which 10 percent of the material is finer by weight.

As shown on Figure 6-5, finer-grained materials provide a lower permeability, but at the expense of berm stability. Sources C-2 and B-4, with a D_{10} of 0.2 to 0.3 millimeter (mm), provide an optimal balance of material properties with the lowest possible permeability that will also meet the seismic stability requirements for the berm; in addition, these sources comply with the grain size specifications for select fill, as presented in the Construction Specifications (Appendix C). For comparison, a D_{10} of 0.3 mm was assumed for the groundwater modeling work described in Appendix A.

6.5.2 Solids Retention of Containment Berm

The select fill material specified for the construction of the containment berm will also serve to retain solids as water flows through the dredged material and into the berm. An analysis was completed to assess the filtering function of the berm to retain the dredged material solids.

Composite samples from prospective removal areas in nine potential AOPCs in Portland Harbor were prepared for chemical mobility testing (LWG 2008b), as well two additional samples from T4 Slip 3. In total, ten AOPCs were evaluated for placement in the T4 CDF. These bulk composite samples were analyzed for grain size distribution. The overall description of these Portland Harbor sediments ranges from silty sand or clayey silty sand to sandy silt or clayey sandy silt. The D_{15} of these sediments ranges from 0.004 to 0.016 mm, averaging approximately 0.008 mm; and the D_{85} ranges from 0.13 to 0.50 mm, averaging approximately 0.25 mm. The specified gradation for the select fill has a D_{15} ranging from 0.18 to 0.70 mm.

Cedergren (1989) recommends the following ratios be met for proper design of a filter material to retain solids:

- [a] (D_{15} select fill)/(D_{85} dredged material) < 4 and
- [b] (D_{15} select fill)/(D_{15} dredged material) > 5

For the select fill specified and the dredged material being evaluated for placement in the T4 CDF, equation [a] ranges from 0.7 to 2.8, and equation [b] ranges from 23 to 88. This indicates that the select fill used to construct the berm should retain the dredged material placed within the CDF.

The use of a geotextile filter fabric was also evaluated for solids retention. The filter fabric would essentially serve the same function as the select fill. The filter fabric would be anchored towards the top of the berm and rolled down the slope to the toe. Panels would be overlapped 3 feet and not seamed. An underwater diver would likely be required to secure the panels in the portion placed beneath the water. Because the fabric does not improve the solids retention capabilities beyond those provided by the 200-foot-wide berm, which is an integral component of the CDF design, and because the cost is high relative to the expected benefit, the use of a filter fabric was not considered further in the design.

7 HABITAT MITIGATION

Construction of the CDF will require discharge of fill materials into Slip 1 to construct the containment berm, and discharge of dredged sediments into the CDF for final isolation of contaminated material. Discharge of fill materials during construction of the CDF triggers the need for compensatory mitigation due to the permanent loss of aquatic habitat as required by the CWA, Section 404(b)(1).

This 60 Percent CDF Design document is not proposing any specific habitat mitigation as the habitat mitigation components that will be conducted to offset losses of aquatic habitat in Slip 1 from construction of the CDF will be determined during the Phase II Removal Action design phases after the Portland Harbor ROD is issued. Habitat mitigation costs for all disposal options, including the T4 CDF, will be included in the alternatives screening evaluation in the Portland Harbor FS, and the T4 CDF will be included as part of the Harbor-wide CWA 404(b)(1) memorandum, which will be an attachment to the FS and will identify a process for determining mitigation requirements for remedial action activities. This document summarizes the activities that have occurred to date per the protocol for selecting a mitigation project that is outlined in the USEPA-approved EE/CA (BBL 2005) and acknowledges that the mitigation requirement would be determined post-ROD and would be consistent with agreements reached in the Harbor-wide FS on how to determine mitigation under Section 404 of the CWA.

As part of the full Removal Action 30 and 60 Percent Design phases, the Port completed and submitted a Conceptual Mitigation Plan Proposal (CMPP; Anchor 2006e), as well as a Draft Mitigation Plan (Anchor 2006f) to USEPA and its federal, state, and tribal partners. The CMPP represented the initial step in identification and documentation of compensatory mitigation activities proposed by the Port, and the Draft Mitigation Plan presented the proposed mitigation package, including on-site actions and the off-site project selected from the options presented in the CMPP. Additional details related to the mitigation activities the Port has completed to date related to Phase II are provided below.

7.1 Summary of Mitigation Activities through 60 Percent Design of Full Removal Action

The Port conducted mitigation activities through the 60 Percent Design phase of the full Removal Action project following the steps for identifying appropriate mitigation project(s) that were described in Appendix Q (Section Q-7.2.1) of the EE/CA (BBL 2005). The steps the Port followed, and the results, are described below:

1. **Conduct a habitat assessment of the Removal Action area.** This assessment was done to refine the characterization of affected habitat provided in Appendix Q of the EE/CA (BBL 2005) based on the design of the Removal Action by describing the biological and physical characteristics of the habitat in the Removal Action area. The results of the habitat assessment identified that 13.98 acres of aquatic habitat would be lost in Slip 1 from construction of the CDF. Of the 13.98 total acres of aquatic habitat, only 1.09 acres, or approximately 8 percent of the total aquatic habitat, would be in the less than 6-foot depth range, which is the most important depth stratum for juvenile salmonids. Within this 1.09 acres, over 85 percent is steep sloped, armored with large riprap, and/or covered with overwater structures. Additionally, a total of 2.19 acres would be within the 6- to 20-foot depth stratum, which represents about 16 percent of the total aquatic habitat impacted in Slip 1. Within this 2.19-acre area, there is a similar trend, whereby approximately 85 percent of the area is either steep sloped, armored with large riprap, and/or covered with overwater structures. A total of approximately 10.7 acres, or about 75 percent of the total aquatic habitat that could be impacted at T4 from construction of the CDF, is in the greater than 20-foot depth range, which is plentiful habitat in the Lower Willamette River.

   The Portland Harbor 404(b)(1) memorandum will consider the mitigation requirements for the T4 CDF. The results of that process will be applied to the Mitigation Plan that will be updated during the design of the Phase II Removal Action post-ROD.

2. **Identify options for proposed mitigation project(s) and determine feasibility of each option.** After meeting with USEPA and its federal, state, and tribal partners during the summer and fall of 2006, three projects were identified as potential compensatory mitigation projects, including Swan Island; Ramsey Lake Refugia, Phase II (financial contribution); and Miller Creek (mitigation bank). In addition to the off-site options, on-site mitigation actions were also selected for inclusion in the proposed mitigation package. On-site actions included creating a small amount of shallow water habitat through capping; placing a sand and gravel layer over the armor layer of the cap in Wheeler Bay; and vegetating the slope in Wheeler Bay and placing large woody debris. Additional on-site activities, including creation of a shallow water area on the CDF berm and removal of 1,800 piling, were initially included in the mitigation package, but were later removed due to discussions with USEPA and its federal, state, and tribal partners.

3. **Prepare a CMPP, which describes the identified off-site mitigation options listed above and evaluates the feasibility of each option.** The Port prepared and submitted a CMPP (Anchor 2006e) as part of the 30 Percent Design documents for the full Removal Action project.
4. **Identify the off-site mitigation project.** A project was selected based on a comparison of options that considered both habitat and programmatic details. As part of this step, the Port met with USEPA and its federal, state, and tribal partners. During the meeting, the Port presented conceptual details of the potential mitigation projects, including drawings and limited engineering characterization needed to support approval of a preferred project. Based on the results of the project comparison exercise, the stakeholder group discussed the scores and selected the Ramsey Refugia, Phase II project. This project will re-establish hydrologic connectivity to the Lower Columbia Slough over 5 acres to reclaim and improve floodplain wetland functions (forested wetland and soft bottom, mud backwater sloughs) and to increase the amount and quality of off-channel rearing and refuge habitat.

The Ramsey Refugia, Phase II project was selected based on the habitat and scale of the project relative to the habitat that would be lost from Slip 1; the implementability of the project; the demonstrated success of the Ramsey Refugia, Phase I project in attracting a variety of fish species, including juvenile salmonids; and the desired characteristics previously communicated by resource agency personnel, particularly NMFS and the U.S. Fish and Wildlife Service (USFWS). In addition, the group of stakeholders asked the Port to further evaluate the feasibility of a second project, Miller Creek, since some members of the group favored Miller Creek over the Ramsey Refugia, Phase II project. In response, the Port initiated discussions with the landowner, but the landowner was unwilling to use the land as a mitigation site.

5. **Prepare a Draft Mitigation Plan.** This document (Anchor 2006f) was prepared after the mitigation project had been identified and was submitted to USEPA as part of the 60 Percent Design documents for the full Removal Action project (Anchor 2006b). The plan identified the on-site and off-site proposed mitigation actions, the potential benefits to salmon and other aquatic species, project logistics, and timing. As the selected project involves the Port providing a certain amount of funding for the implementation of the project, no specific design details were provided in the Draft Mitigation Plan. As part of the submittal, the Port provided semi-quantitative documentation of how the proposed on-site and off-site mitigation options offset losses of habitat in Slip 1, as requested by USEPA.

   It is anticipated that the Draft Mitigation Plan will be updated post-ROD as the Phase II design progresses, and will reflect any Harbor-wide agreements reached during the FS process.

6. **Prepare a Final Mitigation Plan (100 Percent Design) once the Draft Mitigation Plan has been approved.** It is anticipated that the Final Mitigation Plan will be submitted along with the 100 Percent Design documents for Phase II of the Removal Action. The nature of this 100 Percent mitigation design submittal may vary depending on whether the mitigation action is a stand-alone Port project, or if the Port is

contributing to another project in the region, like the Ramsey Refugia, Phase II project.

The Port and USEPA and its federal, state, and tribal partners convened for a meeting in December 2006 to discuss the Draft Mitigation Plan (Anchor 2006f). Comments discussed during this meeting resulted in the removal of the on-site mitigation activities, except for the vegetation planting and placement of large woody debris in Wheeler Bay. In addition, the Port received comments on the Draft Mitigation Plan in January 2007 as part of USEPA's 60 Percent Design comments for the full Removal Action. The comments received in meetings and on the Draft Mitigation Plan are summarized below:

- Final agreement between the Port, USEPA, and a third party needs to be reached before USEPA can approve the Mitigation Plan. Additionally, the agreement details need to allow USEPA to comment on the design to ensure that ARARs are being met.
- Consider the timing of the habitat loss versus the timing of implementation of the mitigation project.
- Include complete plans and specifications for construction in the Final Mitigation Plan.
- Address the temporal loss of habitat in dredging and capping areas.
- Consider species other than salmon.
- Address the replacement of the berth structure.
- Eliminate piling removal and habitat bench along CDF berm from the mitigation package.
- Refine performance criteria related to the acreage created as part of the project, topography, and fish presence.
- Update monitoring timeframes beyond 5 years.

7.2 Next Steps

The Port is not proposing any specific mitigation in this document and acknowledges that determination of final mitigation requirements for the Phase II Removal Action, and construction of the CDF, are uncertain at this time and will be established in cooperation with USEPA, consultation with NMFS, and coordination with other stakeholders post-ROD. The determination of the final mitigation requirements for Phase II will consider agreements reached through the FS process related to the determination of mitigation requirements, as well as any applicable information provided in the Draft Mitigation Plan developed during the full Removal Action 60 Percent Design phase, in which the Port prepared a quantitative analysis of a 5-acre area that creates and/or restores shallow water off-channel habitat as mitigation to offset impacts related to the full Removal Action, including construction of the CDF in Slip 1. The Port received initial feedback from NMFS on this document and was in the process of addressing those comments when the IDR process began.

8 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

USEPA identified location-, chemical-, and action-specific ARARs for CDF construction activities in the Action Memo (USEPA 2006a). Although these activities do not require federal, state, or local permits, they must comply with the substantive requirements of these permits, as detailed in Table 8-1. Federal, state, and local permits are required for any off-site actions.

Since issuance of the Action Memo, there have been some discussions between the LWG and USEPA related to ARARs that could impact activities related to the CDF construction. For example, on January 6, 2010, USEPA provided the LWG preliminary identification of ARARs for development of the Harbor-wide FS. The LWG and USEPA have been undergoing a series of technical discussions regarding application of the ARARs for FS evaluation purposes. Ongoing discussions between USEPA and the LWG regarding ARARs will be presented in the Harbor-wide FS. For this document, Table 8-1 has been reviewed and updated based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between USEPA and the LWG dated February 1, 2010 and February 10, 2010. Note that subsequent conversations and emails occurred that are not reflected in Table 8-1, and the dialogue regarding Harbor-wide ARARs stopped without resolution as it was determined to first allow the FS process to progress. The Harbor-wide ARARs are not final and are subject to change through the FS process.

9 CONSTRUCTION SCHEDULE AND SEQUENCING

Construction of the T4 CDF will be completed in three main stages as summarized below:

- **Stage 1** – Construction of the CDF containment berm.
- **Stage 2** – Filling of the CDF with contaminated sediments from Portland Harbor AOPCs.
- **Stage 3** – Completion of the CDF cover.

In-water work for this project will comply with the timing restrictions specified in the in-water work window that have been determined by ODFW (2000), when salmonids are expected to be present in very low numbers. In the Lower Willamette River, the work window is in the summer and early fall, from July 1 through October 31, and in the winter, from December 1 through January 31. As an additional conservation measure, in-water work will be limited to the late summer and fall in-water work window, from July 1 to October 31. After the berm is built and Slip 1 is isolated from the river, work in the CDF will not be bound by these windows.

9.1 Stage 1 – CDF Containment Berm Construction

This stage of the project will occur over a 2-year period. The first year will be preparation of Slip 1 for filling, as well as constructing the containment berm at the mouth of the slip. The construction elements associated with Stage 1 include the following:

- Slip 1 Preparation
  - Demolition
  - Replacement berth construction
- Stormwater Outfall Rerouting
- Containment Berm Construction

Stage 1 work will take 1 year to complete. Figure 9-1 presents the anticipated duration and sequencing of the different Stage 1 events. The figure also shows the fish closure periods. Each of the elements is described in more detail below.

9.1.1 Slip 1 Preparation

In order to create a CDF in Slip 1, a number of structures need to be demolished and/or relocated. Berths 405 and 408 will be demolished to make room for the CDF (see Section 5.7). This work will be completed with predominantly water-based equipment, with some support from upland equipment. Because work will be conducted from the water, the construction of the containment berm cannot begin until the demolition is completed. Demolition of Slip 1 piers will begin immediately at the beginning of the in-water work window and will take 5 to 6 weeks. Due to the limited duration of in-water work windows, the contractor will work 6 days per week for these activities and for all of the water-based work.

Berth 405 will be replaced with a replacement berth near the containment berm (see Figure 5-9 and Section 5.9). This work is estimated to take 4 months to complete. The footprint of the new pier is offset from the berm footprint, so work on the two structures can occur concurrently without much schedule impact on the other.

Another element of preparing Slip 1 for filling is the relocation of the stormwater outfalls. As described in Section 5.8, four Port outfalls and one City outfall are known to discharge into Slip 1. The rerouting of the outfalls is estimated to take 6 months to complete. The majority of the work will occur out of water, so it can be completed outside the in-water work window. The daylighting of the outfalls into the Willamette River is in-water work that can only be completed during the in-water work window. The relocation needs to occur before the CDF berm breaks the water surface at the mouth of Slip 1 and breaks the hydraulic connection.

9.1.2 Containment Berm Construction

Section 5.2 describes the construction of the containment berm. The first task will be overexcavation of the soft sediments below the berm. Removal of this approximately 25,000 cy will be completed with an 8-cy clamshell bucket and bottom-dump barge. The work will be completed in 5 to 9 days. The overexcavation will then be backfilled with select fill. Once the overexcavation is filled to grade, the contractor will start placement of training terraces. The training terraces will be constructed with an 8-cy clamshell bucket or with a skip box. A skip box is a bucket shaped like the bed of a dump truck. Material is placed by lifting one end of the box while moving it over the target area. Once the terraces are constructed on each side of the berm, select fill will be placed in between. The contractor will use a bottom-dump barge as much as possible to place the select fill. The containment berm will require approximately 290,000 tons of select fill and 95,000 tons of rock for training terraces.

The total duration of berm construction is anticipated to be 5.5 to 6 months. Because of this timeframe, the construction of the berm will be completed using two approaches. The lower portion of the berm will be constructed from the water until the closure of the in-water work window (October 31). The top elevation of the berm at this date is anticipated to be between 4 to 8 feet NGVD, which is expected to be above the water level. The berm will then be finished in the dry with upland-based equipment. This equipment will include trucks hauling in materials, dozers spreading the material, and equipment to compact the lifts.

Once the berm has sealed off the slip from the Willamette River, fish removal in Slip 1 will begin. This process is estimated to last 3 to 5 days.

9.2 Stage 2 – Filling of the CDF with Portland Harbor Superfund Site Sediments

The CDF can confine an estimated 670,000 cy of contaminated sediments. Additional material (200,000 to 300,000 cy) beyond that volume may also be placed in confinement depending on the amount of settlement that occurs. The speed at which the material is placed within the CDF is a function of two factors: 1) how fast the material can be physically offloaded from barges and pumped into the CDF; and 2) how available the material is. The offloading facility to be located at the replacement berth would likely be sized to offload 2,000 to 4,000 cy per day assuming a 10- to 12-inch-diameter hydraulic dredge pump, respectively. Assuming there are 100 working days per in-water work season (6 days per week between July 1 and October 31), the maximum quantity of material that could reasonably be offloaded would be 200,000 to 400,000 cy.

The filling process is estimated to take up to 4 years to complete, although it could take longer or shorter depending on the schedule of the Harbor-wide remedial action and the availability of suitable dredged material. In particular, the filling process may be limited by the progress of remedial actions occurring elsewhere in Portland Harbor.

9.3 Stage 3 – Placement of the CDF Cover

The CDF cover consists of two layers (see Figure 5-2). The lower level, located directly above the confined dredged sediment, is the import fill layer. The volume of this layer is approximately 464,000 cy. The majority of this material is anticipated to be suitable dredged material brought to the site on haul barges. It will be necessary to coordinate with USACE and fulfill the substantive requirements of a CWA Section 404 permit to place suitable dredged material from maintenance dredging activities in the import fill layer. Acceptance criteria, including numeric chemical criteria, for the use of dredged material as part of the import fill layer will be developed during 100 Percent Design.

The offloading facility described in Section 5.4.1 will be used for offloading the material. As with the contaminated sediment, the rate of placement will be a function of the supply rate. At a minimum, the filling would require 1 to 2 seasons to complete.

The top of the CDF is the CDF cover layer. This layer consists of approximately 272,000 tons of aggregate. This material will be from an upland source, brought to the site by truck and/or barge and offloaded. It is anticipated that offloading by barge would be done mechanically. The fastest rate that this material could be placed is estimated at 2,000 tons per day. The filling could be completed at any time during the year since it does not involve in-water work. This layer would require 6 to 12 months to construct.

10 ENGINEERING COST ESTIMATE

The T4 CDF 60 Percent Design Engineering Cost Estimate details the anticipated costs necessary to implement the T4 CDF construction. The cost estimate includes direct and indirect construction costs.

Each of the main costs is summarized below by the different stages of construction. A more detailed account of the cost estimate basis and assumptions is provided in Appendix L.

Stage 1 Construction	**Cost in $Million**
Overwater structure and miscellaneous demolition	$5.7
Stormwater and outfall structures relocation	$2.0
Containment berm construction	$11.4
Replacement berth construction	$4.2
Stage 2 Construction	
Place contaminated sediment[1]	$0
Stage 3 Construction	
Place imported fill	$2.1 to $13.8
Place CDF cover layer	$5.4
Other costs associated with each of the stages:	
Mobilization/demobilization	$0.8
Water quality monitoring	$0.3
Habitat and other mitigation	$1.5 to $5.0
Indirect construction costs	$3.0 to $4.3
Long-term monitoring and maintenance	$1.5
Construction contingency (15%)	$5.7 to $8.2
Total Estimated Cost	**$43.6 to $62.6**

[1] It is assumed that the cost of dredging, hauling, and placement of contaminated sediment will be borne by the parties that generated the dredged sediment and, therefore, those costs are not included here.

11 ACCESS AND EASEMENT REQUIREMENTS

As stated in Section IX (Access and Institutional Controls) of the AOC (USEPA 2003a), the Port shall provide USEPA and its representatives, including contractors, with access at all reasonable times to the T4 area for the purpose of conducting any activity related to the AOC, including construction of the CDF. The AOC further states that if any portion of the T4 area, or any other riparian property where access is needed to implement the Order, is owned by or in the control of someone other than the Port, the Port shall use best efforts to obtain all necessary access for performing and overseeing the construction of the CDF.

The Port owns a majority of the uplands adjacent to the CDF and leases some areas to its tenants. As stated previously, current tenants at T4 near Slip 1 are Cereal Food Processors, IRM, Rogers Terminal, KMBT, and Union Pacific Railroad. As necessary, the Port will develop agreements with Port tenants to coordinate the work necessary for CDF construction.

Currently, both the Port and DSL own the submerged and submersible lands within T4. The Port is in the process of acquiring the land that would be necessary to site the CDF from the State of Oregon. The Port submitted a Land Sale Application Form to DSL in May 2005, which was presented and approved for negotiations at the June 2006 State Land Board. The Port has been, and will continue to be, in discussions with DSL as the CDF design progresses to acquire the remaining submersible land from DSL.

12 INSTITUTIONAL CONTROLS

Institutional controls will be required to ensure that the integrity of the CDF is maintained over the long term. Section IX (Access and Institutional Controls) of the AOC (USEPA 2003a) states that *"If after the Removal Action is complete* [including construction of the CDF]*, restrictions on the use of the Port's property, including the beds or banks of the slips or Willamette River, is necessary to maintain the Removal Action or avoid exposure to hazardous substances, pollutants, or contaminants, the Port shall take any and all actions to establish, implement, and maintain the necessary institutional controls."* In accordance with this requirement, this section describes the institutional controls that will be implemented after the CDF is built.

The overall protectiveness of the CDF will be further enhanced by implementation of institutional controls for areas where contaminated sediment is contained in place. The primary objectives for the institutional controls include protecting the integrity of the CDF berm and its ability to provide confinement of the contaminated sediments placed behind it, and protecting the integrity of the CDF such that the confined contaminated sediments, as well as groundwater in direct contact with these sediments, are not exposed through ingestion or contact with site workers or aquatic life, and do not re-enter the river.

Additional details regarding the institutional controls that will be implemented at the T4 CDF are provided below:

- **Regulated Navigation Area.** A request for a regulated navigation area (RNA) for the CDF berm will be submitted to the U.S. Coast Guard (USCG) and/or the National Oceanic and Atmospheric Administration after the berm is constructed. An RNA designation will prohibit such activities as anchoring, dragging, trawling, or other actions that may disrupt the function or affect the integrity of the CDF berm. The CDF berm will be designed to handle pile driving and removal within its footprint, and to accommodate ship berthing, tugs, and other marine traffic.
- **Update the T4 Base Map.** The footprint of the CDF and its containment berm will be placed on the T4 base map to alert personnel conducting future construction activities

that the integrity of the CDF berm must be maintained. Additionally, all development projects at the Port pass through multiple stages of internal stakeholder review during planning, design, and construction of a project. Specifically, the Port's management process for soliciting stakeholder feedback on a project is called a "Business Analysis Terms Sheet" (BATS). BATS requires solicitation of input from various departments within the Port, including environmental, and provides the opportunity to ensure coordination prior to conducting any invasive construction activities within the CDF footprint.

- **USEPA and Port Notification and Review of Construction Activities.** The confined contaminated sediments will be located 22 feet below the ground surface of the CDF. To ensure the integrity and protectiveness of the CDF, the following activities shall not be conducted on the CDF without adequate supporting technical analysis and USEPA and Port review and approval:
  - Installation of piles driven through the contaminated sediment zone
  - Installation of engineered stormwater infiltration facilities
  - Installation of utilities, storm drain lines, and other conduits under or within the contaminated sediment zone
  - Installation of groundwater extraction wells
  - Installation of foundations within 3 feet of the contaminated sediment zone
- **Tenant Lease Language.** Specific lease language will be provided to future tenants who may occupy the land above or adjacent to the CDF. The lease language will require that all below-grade excavation, construction, or other invasive activity that might potentially disturb the containment must be approved by the Port's Marine Environmental group and, if necessary, USEPA, prior to conducting such work. The lease will also include a groundwater use restriction that prohibits extraction of groundwater from the CDF for ingestion and dermal contact.
- **Restrictive Covenant/Easement and Property Record Notice.** A restrictive covenant or easement that runs with the land and is enforceable against future landowners will be recorded on the title of the property containing the CDF. The restrictive covenant or easement will institutionalize the land use, excavation, and groundwater use

restrictions described above for the property. In addition, a notice will be placed in the property record documenting the CDF location and the long-term monitoring and maintenance requirements as described in the LTMRP.

13 CONCLUSIONS

The T4 CDF, as designed, meets the intent of the USEPA CDF performance standards, as well as Portland Harbor RAOs and ARARs as they are currently known. Among the key CDF performance standards are those that address short-term and long-term water quality effects, berm stability, flood storage capacity, import material specifications, long-term monitoring requirements, habitat mitigation requirements, and institutional controls.

Short-Term Water Quality. Dredging, filling, and related sediment-disturbing CDF construction activities will be conducted in a manner that meets water quality criteria at specified points of compliance. Proposed monitoring methods, measurement parameters, locations, and frequencies are presented in the WQMP (Appendix E), and will be further detailed in the USEPA WQMCCP to be developed during 100 Percent Design. Based on the results of dredging elutriate tests, the favorable monitoring record during the T4 Phase I Removal Action, and the relatively low contaminant concentrations in the berm key area, adverse short-term water quality effects are not expected during T4 CDF construction.

Long-Term Water Quality. A long-term groundwater model of the CDF was developed to predict chemical concentrations exiting the CDF to the river for decades and centuries into the future. The model used leachate data from potential dredged material within the Willamette River. The following conclusions are supported by the groundwater modeling results (see Section 6.4 and Appendix A for further details):

- Groundwater transport pathways are dominated by downward vertical flow through the contaminated sediment toward the underlying aquifer and laterally into the berm.
- The groundwater residence time in the contaminated fill material varies from less than 20 years along the front and bottom of the CDF, to greater than 200 years at the upper rear of the CDF. Therefore, contaminated sediments in the rear and upper portion of the CDF are likely to have less effect on groundwater exit concentrations.
- During the model simulation period, the centerline and spatially averaged concentrations of all COCs remained below their respective evaluation criteria—including chronic water quality criteria, fish consumption criteria, and drinking

water MCLs—under the base case scenario of no biodegradation, except for Total PCBs, which reached its fish consumption criterion at approximately 500 years. Groundwater exit concentrations for copper, DDx, and Total PCBs remained below Portland Harbor upstream background concentrations, and all organic COCs remained below analytical reporting limits for at least 500 years.

- When conservatively slow rates of biodegradation are incorporated into model simulations for organic compounds, the maximum groundwater concentrations exiting the berm are reduced by two to three orders of magnitude.
- Model sensitivity and uncertainty analysis was conducted to assess the robustness of the model predictions to variations in sediment fill permeability, berm permeability, berm organic carbon content, dredged sediment leachate concentrations, berm Koc values, and biodegradation rates. Using a realistic range of input parameter values and a conservatively slow biodegradation rate, none of the sensitivity scenarios were predicted to exceed water quality criteria.
- The mass loading of contaminants in groundwater exiting the CDF constitute a negligible percentage of the upstream load to Portland Harbor, as well as a negligible percentage of the existing load from in situ contaminated sediments in the Harbor. Dredging the contaminated sediments in the Harbor and placing them in the CDF is expected to result in greater than 99.99 percent reduction in the mass loading of PCBs and DDx to the river (excluding consideration of sediment from AOPCs 9 and 14) compared to the contaminant loading that would occur through dissolution and resuspension if the sediments were allowed to remain in place in the river and were not remediated.

Berm Stability. The berm has been designed to provide a static safety factor of 1.5 or greater and a seismic safety factor of 1.1 or greater, based on a design seismic event corresponding to a 10 percent probability of exceedance in 50 years (see Section 5.2.2 and Appendix H). The berm has been designed to resist erosion from 100-year floods, 100-year waves, and propeller wash and waves from vessels maneuvering at or near the terminal (see Section 5.2.3 and Appendix G). The CQAP (Appendix D) provides QC measures that will be implemented during construction to verify that the CDF is built in accordance with the project Drawings (Appendix B) and Construction Specifications (Appendix C).

Floodway Impacts. Based on hydraulic modeling of the Willamette River (using the USACE HEC-RAS model), it has been demonstrated that the CDF will not measurably increase the 100-year flood elevations or decrease the flood storage capacity of the river, in accordance with FEMA regulations (see Section 5.6 and Appendix I).

Import Material Specifications. The materials used to construct the CDF elements (including the berm, contaminated sediment fill, and cover layer) will meet acceptable physical and chemical characteristics to ensure the facility will be structurally stable and will not cause adverse water quality effects. Contaminated dredged material will be evaluated for placement in the CDF based on the bulk sediment and leachate quality of the candidate sediments. Contaminated sediments will be maintained in a saturated condition by placing them below elevation +9.5 feet NGVD. Numerical sediment acceptance criteria and import material goals will be presented in the Sediment Acceptance Criteria Memorandum to be developed during 100 Percent Design.

Long-Term Monitoring. A long-term monitoring program will be implemented after the CDF is built to ensure that the CDF is functioning as intended and meeting its performance standards well into the future. The long-term monitoring program will include routine visual surveys of the exposed portions of the berm and hydrographic surveys of the submerged portions of the berm for evidence of berm erosion and slope movement; surveying of monuments to assess CDF consolidation and settlement; and installation, monitoring, and sampling of a groundwater well network to assess saturation levels and groundwater quality in the CDF (see Section 6.4 and Appendix A). Details are outlined in the LTMRP (Appendix K), which will be further developed during 100 Percent Design.

Habitat Mitigation. The Port is not proposing any specific mitigation in this document, but acknowledges that the determination of final mitigation requirements for construction of the

CDF will be established in consultation with USEPA and its federal, state, and tribal partners after the ROD is issued.

Institutional Controls. The integrity of the CDF will be protected through the use of institutional controls such that the confined contaminated sediments, as well as groundwater in contact with those sediments, are not exposed to site workers or aquatic life (see Section 12). Institutional controls will include requesting a regulated navigation area designation from USCG, requiring construction notifications to the Port and USEPA, general restrictions regarding subsurface disturbances in the CDF (e.g., installation of utilities, piles, wells, foundations, etc.), tenant lease restrictions, and recording a restrictive covenant or easement that runs with the land on the title of the property.

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